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GEOLOGY AND DRILLING HISTORY
OF THE
LANIPUNA #1 GEOTHERMAL TEST,
TOKYU LANDS PROSPECT,
HAWAII

for

BARNWELL INDUSTRIES, INC.

HONOLULU, HAWAII

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by

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INTRODUCTION

The Lanipuna #1 geothermal exploration well is located 900 feet northwest of the Puulena Crater near the center of the Kilauea East Rift. It is approximately 1,800 feet SSE of the Hawaiian Geothermal Project well (HGP-A). The elevation at the well site is 600 feet above sea level.

Access to the drill site is by way of a 1/4 mile of cinder road which intersects Hawaii County Highway 132 approximately 1,000 feet south of HGP-A (figure 1).

Lanipuna #1 was spudded on Monday, February 9. Total depth of 8,389 feet (RKB) was reached at 1,600 hours on Tuesday, May 26 (figure 2). In the course of drilling operations, there were major interruptions in drilling at depths of 1,040 feet and 3,520 feet, where 13-3/8-inch and 9-5/8-inch casing strings were set, at 7,000 feet where the well was surveyed and tested and at 7,132 feet where the drill string separated above the collars and a fishing job ensued.

Lanipuna #1 penetrated a lithologic section of subaerial lava flows (surface to 1,670 feet), shallow marine volcanic rocks (1,670 feet to 3,400 feet) and deep submarine flows (3,400 feet to 8,389 feet). There were no zones of lost circulation encountered below the 13-3/8-inch surface casing, but temperature surveys indicate fluid flow in a zone of permeable rock between the depths of 5,600 and 6,300 feet. A maximum temperature in excess of 686°F (the temperature limit for downhole temperature recording tools) was recorded at a depth of 8,389 feet, approximately 32 hours after displacing mud drilling fluid from the hole with water. The formation temperature at 8,389 feet probably exceeds 700°F, qualifying the Lanipuna #1 as one of the world's hottest geothermal wells.

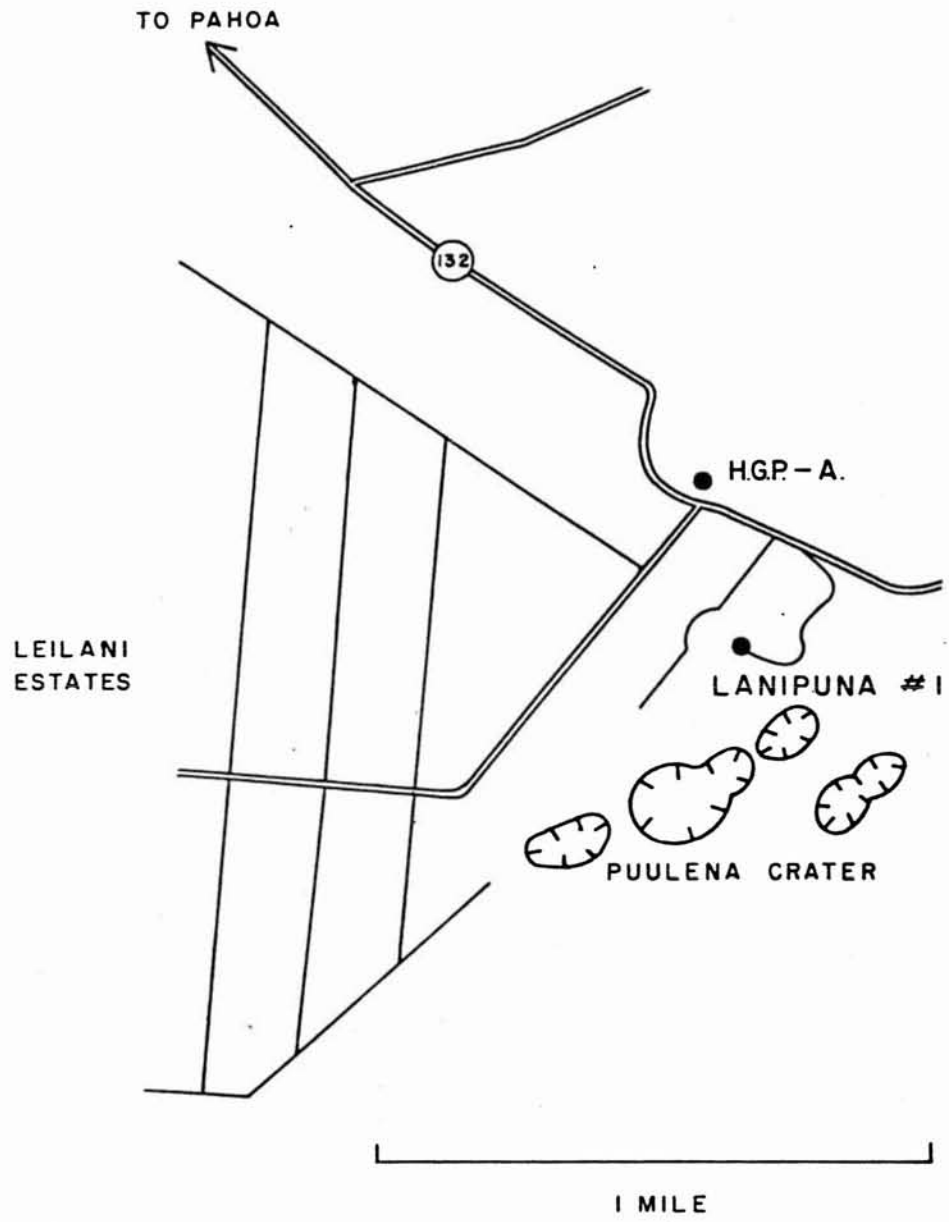

FIGURE 1. Lanipuna #1 — Site Location

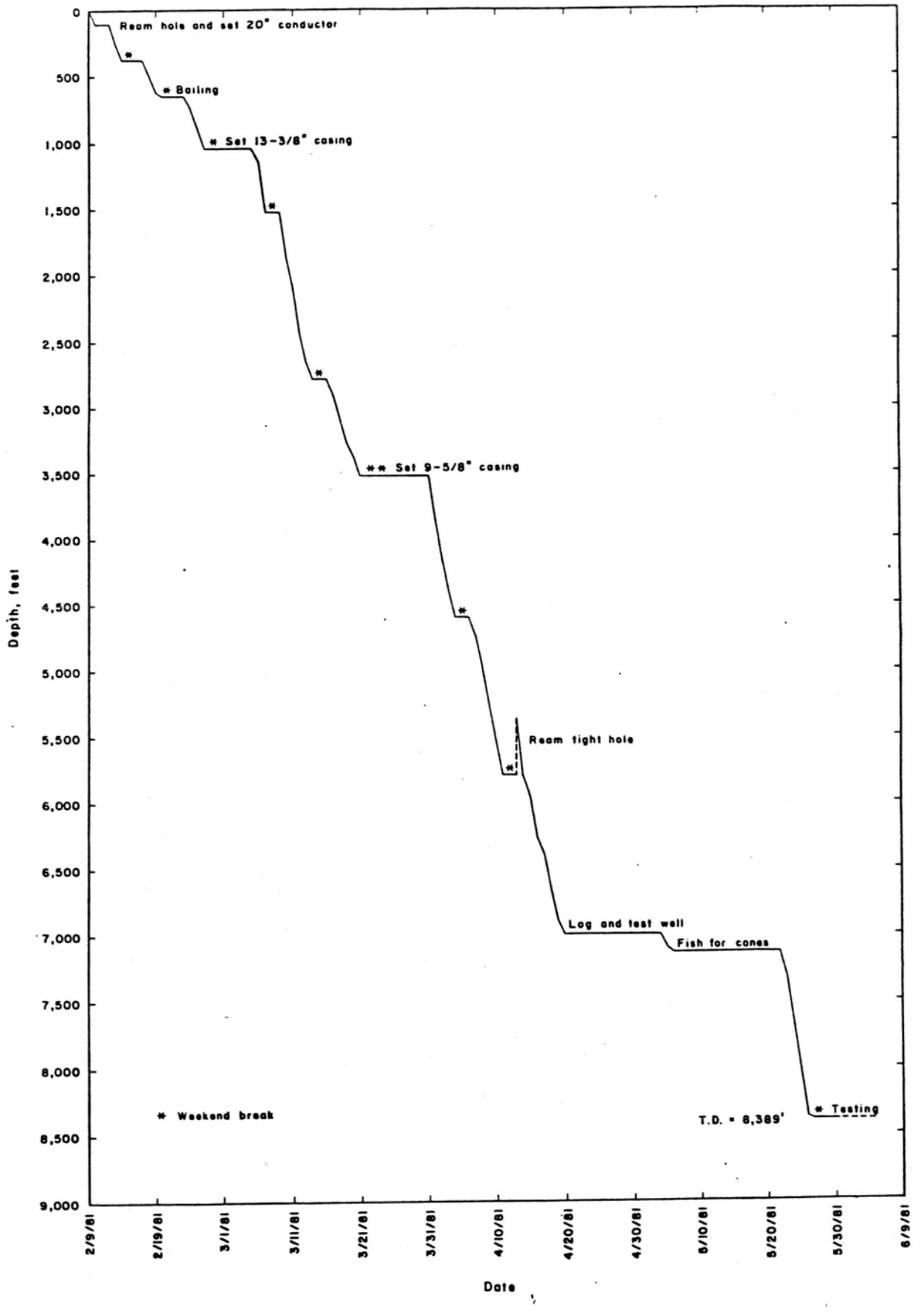

FIGURE 2. Lanipuna #1 Drilling Operations: Depth Versus Time

DRILLING HISTORY

Phase I - Conductor Hole

The Lanipuna #1 was spudded on February 9, 1981. The initial drilling assembly, a 12-1/4-inch button bit beneath a 26-inch hole opener, was used to center punch the pilot hole within the 30-inch flow line. Circulation of the mud drilling fluid was lost at 31 feet (RKB) a few feet below the cellar floor. It was not regained while drilling of the conductor hole.

Once centered, the pilot hole was drilled with an assembly composed of a 12-1/4-inch button bit (Bit #1) and a reamer. The pilot hole was completed to a depth of 102 feet (RKB) at 0630 hours of February 10.

A 17-1/2-inch Smith hole opener was used to ream the 12-1/4-inch hole to a depth of 101 feet. A 26-inch hole opener reamed the 17-1/2-inch hole to a depth of 70 feet (RKB). At 1030 hours on February 11, the 26" drilling assembly was pulled from the hole, and the 30-inch flow line was cut off at the cellar floor. Twenty-inch conductor pipe was run into the hole to a depth of 64 feet(?) and cemented from the surface with 378 cubic feet of construction grade cement. Cement was in place at 1800 hours of February 11.

Phase II - Surface Hole

Drilling the 17-1/2-inch surface hole began at 1130 hours on February 12 from a depth of 101 feet. The drilling assembly included a 17-1/2-inch button bit (#2) and a near bit reamer.

The 17-1/2-inch hole was drilled to a depth of 450 feet with an air foam drilling fluid. From 450 feet to the target depth of 1,040 feet the drilling fluid was mud. Circulation of either foam or mud was never established. Difficulties in making connections and problems with temporarily stuck drill pipe were recurrent but overcome during drilling the 17-1/2-inch hole.

State regulations require sampling of the fresh water aquifer from all wells to determine potability. Bailing operations began on Friday, February 20, when the hole was 650 feet deep. Bailing continued up to the weekend break at 0800 hours on Saturday when a sample of the aquifer was obtained and submitted to the state.

On Monday, February 23, the near bit reamer was dressed, and a new 17-1/2-inch button bit (#3) was secured to the drill string. Drilling

resumed without returns of the mud drilling fluid. At 0100 hours on Thursday, February 26, the target depth of 1,040 feet was reached. In the time remaining before the weekend break, drilling crews pumped mud and lost circulation material down the hole in an unsuccessful bid to establish circulation. At Friday midnight, the rig was secured for the weekend.

Drilling operations began again at Sunday midnight. The hole was reamed and preparations were made to run 13-3/8-inch casing.

The 13-3/8-inch casing was in the hole at 1600 hours on Monday, March 2. The casing extended from the surface to a depth of 1,020 feet. Seventeen barrels of CaCl water and 12 drums of flow check with 20 barrel spacers of water between them were pumped down first to condition the hole. Eight hundred eighty one (881) cubic feet of class G cement with 1:1 perlite, 40% silica flour and 2% gel were pumped down the hole and followed by a tail of 180 cubic feet of class G cement with 40% silica flour. The volume of cement was approximately 1-1/2 times the calculated hole volume, and there were no cement returns to the surface.

After a wait of 6-1/2 hours, 1.6-inch tubing was run down the annulus until it struck cement at a depth of 370 feet. Three hundred (300) cubic feet of class G cement were pumped down the annulus in increments of 50 cubic feet at 2-hours intervals with no returns to the surface. Another 567 cubic feet of ready mix concrete, poured down the annulus, brought cement to the surface at 2100 hours on Tuesday, March 3. Drilling crews installed and tested blowout preventers and prepared to drill the 12-1/4-inch intermediate hole.

Phase III - Intermediate Hole

The 13-3/8-inch casing shoe was drilled at 0230 hours on Friday, March 6, and the drilling operations resumed from a depth of 1,040 feet. The new drilling assembly was composed of a 12-1/4-inch button bit (#4) and a near bit reamer. The 12-1/4-inch hole was drilled with full circulation of mud drilling fluids and lost circulation material. At the weekend break, the hole was 1,528 feet deep.

Drilling the 12-1/4-inch hole resumed on Monday, March 9 and continued throughout the week without major interruptions. On Saturday, March 14, depth of the hole was 2,781 feet.

The following week was equally uneventful. On Saturday, March 21, depth of the hole was 3,520 feet. During the weekend, temperature surveys revealed a bottomhole formation temperature in excess of 270°F. The decision was made to run 9-5/8-inch casing, although the temperature gradient did not suggest that the hole was within 500 feet of a commercial production zones.

On Monday, March 23, the hole was circulated, and the mud conditioned for 2 hours. The 9-5/8-inch casing was run in 2 stages. The first stage was hung as a liner from the 13-3/8-inch surface casing with the 9-5/8-inch casing shoe at a depth of 3,502 feet and the liner top at a depth of 847 feet. After the first stage was in place, the hole was circulated for 4 hours prior to cementing. Twenty barrels of CaCl water and 20 drums of flow check were pumped immediately ahead of the cement to condition the hole. Four hundred eleven (411) sacks of class G cement with 1:1 perlite, 40% silica flour, 2% gel and 0.5% CFR-2 were pumped in the hole and followed by 150 sacks of class G cement with 40% silica flour. Cement was in place at 1730 hours on Tuesday, March 24, and liner hanging tools and drill pipe were pulled from the hole.

Prior to running the second string of 9-5/8-inch casing, cement was washed out of the hole from a depth of 334 feet to a depth of 859 feet, 12 feet within the liner. The second string of casing was run into the hole, stabbed into the liner and cemented to the surface with 236 sacks of class G cement with 40% silica flour. Cement was in place at 2030 hours on Wednesday, March 25. Valves and blow out preventers were installed in the time remaining before the weekend break.

Phase IV - Production Hole

The 9-5/8-inch casing shoe was drilled at 1100 hours on Tuesday, March 31, and drilling resumed from a depth of 3,520 feet. The new drilling assembly consisted of an 8-3/4-inch button bit (#8) and 3 blade stabilizers. The drilling fluid was a light, low solids mud. Drilling of the 8-3/4-inch hole was uneventful during the week. At the break on Saturday, April 4, the hole was 4,595 feet deep with a recorded bottomhole vertical deviation of 1-3/4°.

On Monday, April 6, the three blade stabilizers were removed prior to tripping into the hole. Drilling continued without incident throughout the week, and on Saturday, April 11 the hole depth was 5,795 feet. A Totco survey showed that the vertical deviation had increased from 1-3/4° to 7-1/4°. The rig was not equipped with either monel collars or compass survey tools and directions of deviation were not known.

On Monday, April 13, the three blade stabilizers were put back on the drilling string. After reaming the hole from a depth of 4,865 feet to 5,795 feet, drilling resumed. Although there were no further interruptions in drilling during the week, there was a marked increase in drilling torque. Drilling continued to 1630 hours on Sunday, April 19. Total depth was 7,000 feet.

Drilling mud was displaced from the hole in stages with water in anticipation of testing the well. At 1600 hours on Monday an attempt to

flow the well was initiated. Water was blown from the well with compressed air in stages of 186 feet (6 joints of pipe) from a depth of 800 feet to 3,482 feet. Although a flow was not sustained without the aid of compressed air, water blown from the hole increased in salinity from less than 50 to more than 10,000 ppm, indicating some entry of formation fluids. At 2300 hours on Tuesday, April 21, efforts to flow the well were halted.

Subsequent pump injection tests established rates of 170 gpm at 600 psi and 105 gpm at 450 psi. Temperature surveys (Appendix D) revealed that the hole was taking water around depths of 4,000 feet and 5,900 feet.

From Monday, April 27 to Friday May 1 the hole was surveyed with geophysical logs to satisfy state regulations. In addition, a monel collar was acquired, and the hole was surveyed for the angle and direction of deviation below the 9-5/8-inch casing. It was determined that the hole had drifted northeastward below the 9-5/8-inch casing.

Drilling operations resumed on Monday, May 4, after a three day break. A depth of 7,800 feet was the drilling target, based upon projection of temperature gradients toward a temperature equivalent to the production zones of HGP-A. Water was displaced from the hole with a low solids mud drilling fluid, and drilling commenced. The drilling assembly included an 8-3/4-inch rerun button bit (#11) and 3 blade stabilizers. On Tuesday at 1400 hours the drill pipe was removed from the hole to exchange drill bits. The depth was 7,132 feet. Because drilling torque continued to be excessive, the 3 blade stabilizers were removed from the drilling string prior to tripping into the hole. At a depth of 5,452 feet the trip in was suspended to circulate the mud drilling fluid and cool the bit. During the circulation a drill collar twisted off at the pin, and thirteen 6-3/4-inch collars dropped to the bottom of the hole. It was 0100 hours on Wednesday, May 6. The drill pipe and the damaged collar were chained out of the hole, and fishing operations began.

On Thursday, May 7 at 1600 hours the dropped collars were pulled from the hole beneath an overshot fishing tool. The drill bit cones and an overshot grapple remained at the bottom of the hole. Fishing operations continued to Thursday, May 21. Fishing tools consisted of a junk sub, junk baskets, a reverse circulation basket and two mills. The largest pieces of metal fished from the hole were several inches across. The drill bit journals were milled to about half their original size.

Drilling resumed on Friday, May 22, and continued without incident to 0400 hours on Monday, May 25, when hole depth was 8,048 feet. Drill pipe was pulled from the hole, and the bit was replaced by Bit #14. Drilling continued until 0930 hours on Tuesday, May 26 when drilling operations were halted at a depth of 8,389 feet. The mud drilling fluid was displaced from the hole with water and preparations began to test the well.

DRILLING FLUIDS

Mud temperatures were monitored continuously. A plot of flow line mud temperatures versus depth (figure 3) shows a statistical rise in temperature with depth. Local increases and decreases in temperature reflect the sporadic operation of the cooling tower.

Mud chemistry and chlorides were analyzed on a daily basis (Appendix E). There were no anomalously high values of total chlorides noted during the course of drilling to indicate mixing of drilling fluids with geothermal fluids.

Table 1 lists the types of drilling fluids used during the course of drilling Lanipuna #1. The upper 1,000 feet of hole penetrated subaerial lava flows, and interbedded, permeable breccia zones. As a result, circulation of either mud/gel or air foam could not be established.

During phase III of the operations (1,040-3,520 feet) full circulation of the mud/gel drilling fluid was established. As much as 5% lost circulation material, chiefly bagasse and cotton seed hulls, were run in the drilling fluid at all times.

A low solids mud/gel drilling fluid was used to drill the production hole (3,520-8,389'). There were no observed losses of fluid during the drilling operations, but temperature surveys showed that the hole was taking fluid around a depth of 6,000 feet. A minor delay in drilling at a depth of 7,960 feet due to differential sticking indicated a loss of drilling fluid somewhere within the production hole.

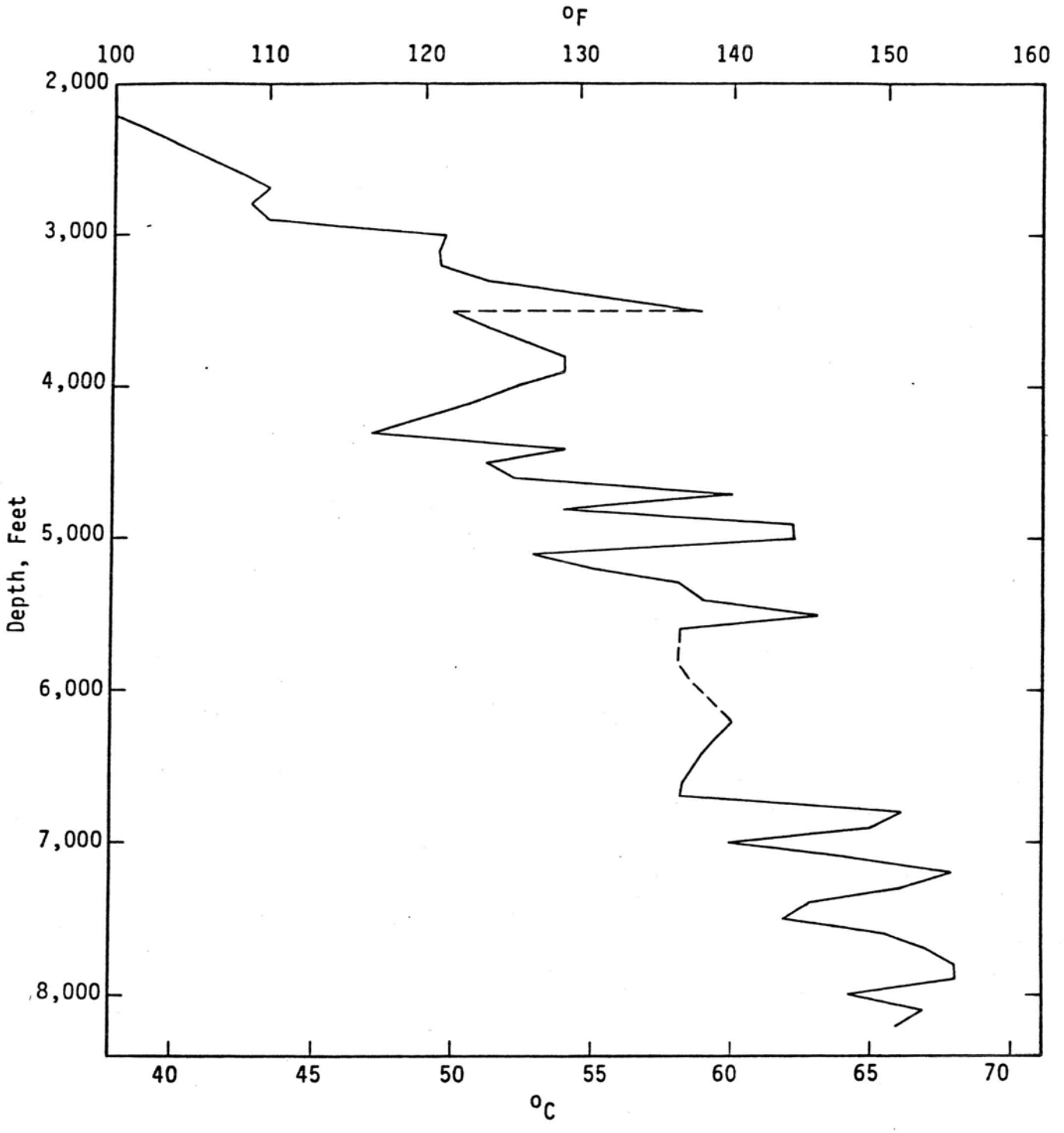

FIGURE 3. Lanipuna #1, Mud Temperatures at the Flow Line.

Table 1. Drilling Fluids

Lanipuna #1 Geothermal Exploration Well

Summary of Operations	Drilled Interval (feet)	Drilling Fluid	Circulation of Drilling Fluid	Range of Viscosity (sec/qt)	Range of Weight (lbs/gal)	Additives to Drilling Mud
Phase I - Conductor Hole						
A. 12-1/4-inch pilot hole	surface-102	mud/gel	Lost at 31	-	-	lime, caustic
B. 17-1/2-inch hole opener	surface-101	mud/gel	none	-	-	lime, caustic
C. 17-1/2-inch hole opener	surface-70	mud/gel	none	-	-	lime, caustic
Phase II - Surface Hole	101-450	air foam	none	-	-	gel, CMC, soda
	450-1,040	mud/gel	none	-	-	-
Phase III - Intermediate Hole	1,040-3,520	mud/gel	full	32-49	8.6-9.2	lost circulation material
Phase IV - Production Hole	3,520-8,389	low solids mud	full	32-40	8.5-9.0	-
Phase V - Hole Clean-out	±4,400-7,900	water and low solids mud	full	32-55	-	-

DIRECTIONAL SURVEY

An 11-point directional survey was run on Monday, April 27 to determine the angle and direction of hole deviation and the location of the hole at depth. Table 2 lists the results of the survey.

The direction of hole deviation was not obtained within the cased hole (surface to 3,502 feet) because metal casing alters compass readings. The average angle of deviation within the cased hole is 2 degrees. The maximum possible drift is 119.12 feet at the 9-5/8-inch casing shoe (3,502 feet).

The 8-3/4-inch hole was drilled from 3,520 feet to a depth of 4,600 feet with 3 stabilizers included as part of the drilling assembly. Hole deviation did not exceed 2-1/2 degrees. The directions of deviation shifted from southeast to east in a counterclockwise spiralling trend (figure 4).

The 8-3/4-inch hole was drilled without stabilizers from 4,600 feet to a depth of 5,800 feet and the inclination of the hole increased to 2-1/2 degrees. The direction of hole deviation continued to follow a counterclockwise spiralling pattern, now trending to the north.

At a depth of 5,800 feet, the three stabilizers were returned to the drilling assembly, and the angle of inclination was arrested at approximately 7 degrees. The direction of hole deviation deflected away from the northerly counterclockwise spiral and swung toward the northeast.

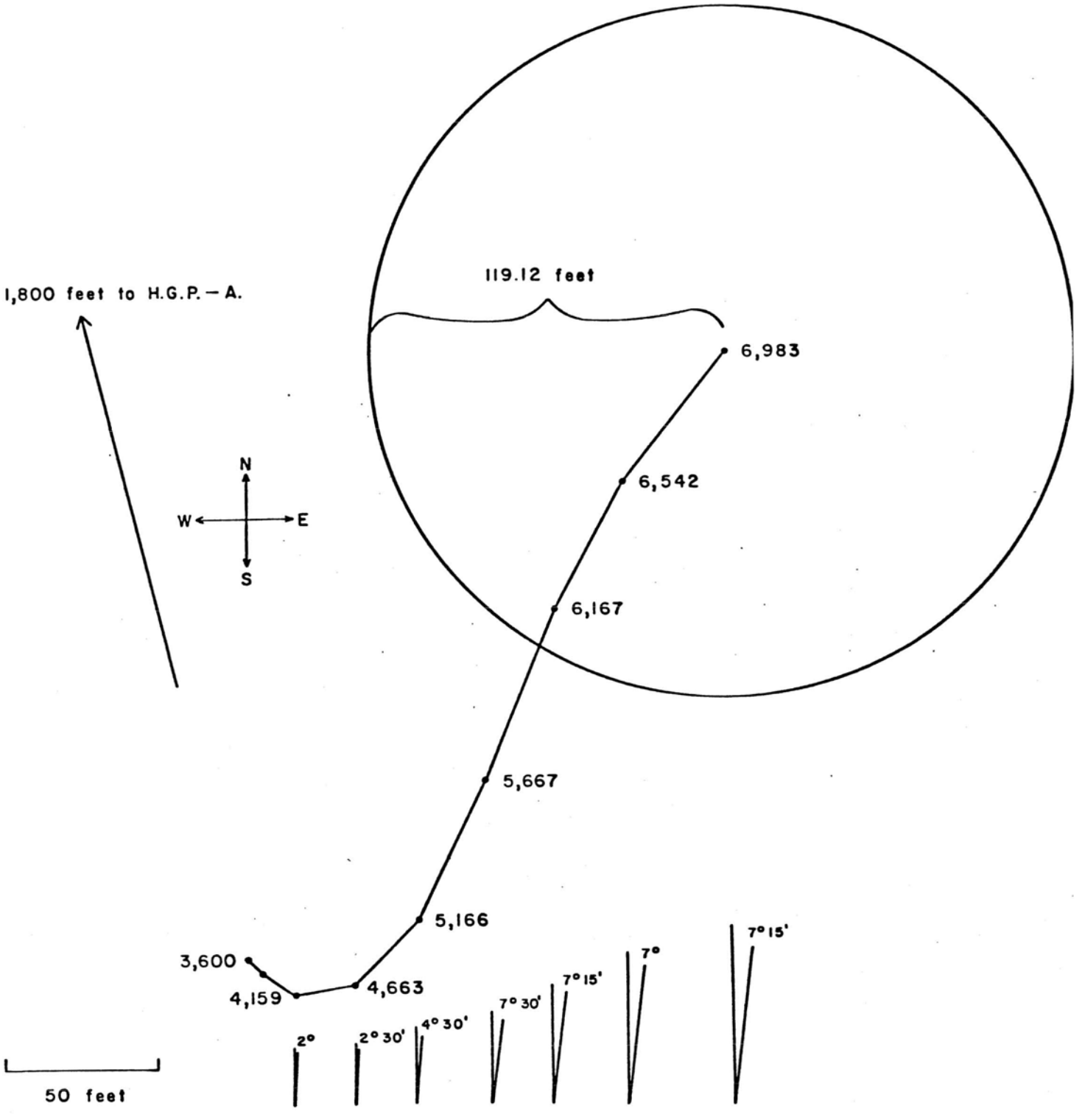

FIGURE 4. Lanipuna #1 — Directional Survey, Map View

Table 2. Lanipuna #1, Directional Surveys

Station No.	Terminal Angle	Terminal Direction	Measured Depth	Course Length	Average Drift Angle	Vertical Depth	True Vertical Depth	Course Deviation
1	2°20'	---	711	711	1°15'	---	710.86	15.55
2	2°	---	2,112	1,401	2°15'	1,399.88	2,110.74	55.06
3	2°	---	3,502	1,390	2°	1,389.17	3,499.91	48.51
4	1°30'	S41E	3,755	253	1°45'	252.88	3752.79	7.72
5	2°	S73E	4,162	407	1°45'	406.80	4,159.59	12.41
6	2°30'	N57E	4,666	504	2°15'	503.60	4,663.19	19.87
7	4°30'	N30E	5,170	504	3°30'	503.04	5,166.23	30.74
8	7°30'	N20E	5,674	504	6°	501.23	5,667.46	52.25
9	7°15'	N23E	6,178	504	7°15'	499.97	6,167.43	63.60
10	7°	N32E	6,556	378	7°	375.17	6,542.60	48.21
11	7°15'	N43E	7,000	444	7°15'	440.45	6,983.05	55.84

Table 2 (continued)

Station No.	Average Drift Direction	Coordinate Differences North	Coordinate Differences South	Coordinate Differences East	Rectangular Coordinates North	Rectangular Coordinates South	Rectangular Coordinates East
1	---------- Maximum drift radius 119.12 feet ----------						
2	---------- Maximum drift radius 119.12 feet ----------						
3	---------- Maximum drift radius 119.12 feet ----------						
4	S41E	---	5.85	5.06	---	5.85	5.06
5	S57E	---	6.76	10.60	---	12.61	15.66
6	N82E	2.75	---	19.62	---	9.86	35.28
7	N43E	22.48	---	20.96	12.62	---	56.24
8	N25E	47.36	---	22.09	59.98	---	78.33
9	N22E	58.97	---	23.82	118.95	---	102.15
10	N28E	42.57	---	22.63	161.52	---	124.78
11	N37E	44.59	---	33.61	206.11	---	158.39

GEOLOGY OF LANIPUNA #1

During the course of drilling operations, samples of drill cuttings were collected at ten foot intervals from just below the 13-3/8-inch casing shoe (1,020 feet) to the bottom of the well at a depth of 8,389 feet. These samples were studied and described at the drill site with the aid of a binocular microscope (Appendix A). Samples for thin section preparation were selected on the basis of observations from the examiniation of well cuttings with the binocular scope, drilling breaks and temperature surveys. Thin sections of drill cuttings were examined and described with the aid of a transmitted light, polarizing microscope.

Stratigraphy

Basalts within the stratigraphic section at Lanipuna #1 were erupted in three very different environments. From the surface to a depth of 1,670 feet, the well penetrated a zone of subaerial basalt flows with associated breccia zones. In general, the rocks can be described as vesicular, hypocrystalline, tholeeitic basalts. Phenocrysts of clinopyroxene (.5-2.5 mm) and plagioclase (.4-2 mm) are common. Phenocrysts of bright green olivine (.5-3 mm), though not abundant, are conspicuous. Groundmass textures are intergranular to intersertal. Granular crystals of pyroxene (.05-.1 mm) and/or brown to black glass fill the matrices between randomly oriented lath-shaped crystals of feldspar (05-.2 mm).

From a depth of 1,670 feet to 3,400 feet the well entered the shallow marine environment. Flows erupting in this environ are typically glassy, due to quenching, and brecciated, due to quenching and explosive degassing. At the drill site, entry into the shallow marine environment is signaled by the appearance of clay in the well cuttings. Petrographic examination of cuttings revealed vesicular to nonvesicular hypocrystalline basalts and hyaloclastite. Unbrecciated flows often contain perlitic fractures or nodules of glass which indicate quenching. Clasts of hyalocastite are composed of brecciated fragments of both glass and mafic phenocrysts.

From a depth of 3,400 feet to the bottom of the well (8,389 feet), the section is composed of basalt flows which were erupted into a deep water environment. They are characterized by an absence of vesicularity and by a wider range of groundmass textures than observed within the overlying sections of subaerial and shallow marine volcanic rocks. These textures range from holohyaline (vitrophyre) to fine, hypodromorphic-granular. hypidiomorphic-granular. Vitrophyre and hypohaline rocks exhibit various degrees of quenching, but with none of the brecciation characteristic of basalts erupted into a shallow marine environment. Fine, hypidiomorphic-granular basalts are composed of crystals of plagioclase and pyroxene of

roughly equal dimensions. The texture commonly forms where crystals accummulate by settling to the bottom of stationary flows.

Alteration

Ellis and Mahon (1977), Kristmannsdotter (1975) and Hoagland and Elders (1978) emphasized the variability and complexity of alteration zoning in geothermal fields. Rock permeability and formation temperature are critical factors which interact to form alteration zones. Temperature regimes limit the types of alteration products which can form in any given rock. For example, zeolite and clay minerals are stable at relatively low temperatures while actinolite or epidote form at higher temperatures. Permeability determines the extent of alteration and may be a factor in the formation of hydrous alteration products. Furthermore, minerals such as calcite and quartz tend to precipitate in permeable rocks in response to changing temperatures.

Table 3 summarizes the alteration in Lanipuna #1. Subaerial basalts are porous and permeable, yet alteration is minimal and probably restricted to deuteric reactions which occur as recently erupted lava cools. Formation temperatures are low and chemical weathering is the dominant alteration process. Hydrous iron oxide forms from the breakdown and oxidation of opaque minerals, and clay is generated by the chemical leaching of feldspars.

Basalts erupted into the shallow marine environment are subject to more extensive alteration and a greater variety of alteration minerals. As previously mentioned, shallow marine flows are subject to rapid cooling and explosive degassing which produce glassy, fractured rock. Glass alters to palagonite and montmorillonite. Zeolites form in fractures and vesicles. Processes which form these minerals initiate upon eruption and lost intensity as the rock cools.

From a depth of 3,000 feet to 5,600 feet the rocks display slight or no alteration. The basalts were erupted at sufficient depths and pressures to inhibit degassing. Most altered rocks are within the glassy, chilled portions of submarine flows, least altered, within the interior portions of a flow. Alteration is restricted to glassy groundmasses and occurs in patches. At these depths formation temperatures are high enough to form extensive alteration. However, permeability and porosity are minimal and inhibit the alteration process.

From 5,600 feet to 6,300 feet, the rocks are extensively and highly altered. Groundmass constituents include actinolite, chlorite, epidote, albite and minor biotite. Although these submarine basalts are not vesicular, fractures are abundant and veins of quartz and, to a lesser

Table 3. Summary of Alteration Zones, Lanipuna #1

Depth, in feet	Vesicular	Extent of Alteration	Alteration Products	Volcanic Environment
Surface-1,670	yes	slight to none	Partial alteration of pyroxene phenocrysts; patchy alteration of glass to palagonite. Minor $FeO^{\cdot}H_2O$.	Subaerial
1,670-3,000	yes	moderate	Alteration of glass to montmorillonite and palagonite. Minor calcite in vesicles; alteration of pyroxene phenocrysts to chlorite. Fibrous and botryoidal zeolites in vesicles (2,480-2,970')	Shallow marine
3,000				
3,000-3,400	slightly	slight to none	Minor montmorillonite; patches of palagonite and cryptocrystalline material. Some alteration of pyroxene to chlorite. Traces of quartz veins.	Transition shallow to deep marine
3,400-5,600	no	slight to none	Patchy alteration of vitrophyre to palogonite and chlorite	Deep marine
5,600-6,300	no	moderate to intense	Phenocrysts and groundmass material are altered to actinolite with minor chlorite, epidote, and albite and trace amounts of biotite and calcite. Veins of quartz are common.	
6,300-7,000	no	slight to intense	Groundmass material is altered to actinolite with minor chlorite, epidote and albite.	

Table 3 (continued)

Depth, in feet	Vesicular	Extent of Alteration	Alteration Products	Volcanic Environment
7,000-7,750	no	slight to intense	Groundmass minerals are altered to actinolite and chlorite with minor epidote, albite and hornblende. Some metamorphic textures. Traces of quartz in vesicles.	Deep marine
7,750-7,900	yes	slight to moderate	Groundmass minerals are altered to actinolite with substantial amounts of chlorite and accessory muscovite and biotite. Vesicles are all filled with chlorite and muscovite.	
7,900-8,389	no	slight to moderate	Pyroxene phenocrysts are altered to actinolite or chlorite and mica. Groundmass constituents are altered to actinolite, chlorite, biotite, muscovite, epidote and albite.	

degree, calcite are common. In this zone the combination of permeability and temperature are evident.

From 6,300 feet to 7,750 feet, the extent of alteration is variable and subject to extremes. Fractured, permeable or porous rocks are local occurrences. Veins of quartz are rare.

Slightly vesicular rocks occupy the zone between depths of 7,750 and 7,900 feet. The zone was marked by a large drilling break and expectations were raised as to an increase in permeability. However, veins of quartz or calcite were not detected in the examination of well cuttings. Vesicles are all filled with chlorite or intergrowths of chlorite and mica, but variable groundmass alteration supports observations of relatively low permeability.

From a depth of 7,900 feet to the total depth of 8,389 feet, the rocks are nonvesicular. Alteration varies from slight to moderate in rocks of low permeability.

In conclusion, the zone of intensely altered and veined rocks between 5,600 and 6,300 feet appears to possess the greatest permeability of any deep, submarine zone. Petrographic observations are reinforced by temperature surveys and drilling breaks. Flow tests will prove if adequate permeability exists at depth to make the well commercial.

GEOPHYSICAL SURVEYS

An electric log, a gamma ray-neutron log and a cement bond log were run at the request of Water Resources International with the hole depth at 7,000 feet.

The cement bond log indicated an excellent bond behind the 9-5/8-inch casing.

The Gamma Ray-Neutron log was run from surface to a depth of 3,500 feet (the 9-5/8-inch casing shoe) to satisfy state requirements.

The electric log (S.P. = short resistivity) was run from a depth of 3,500 feet to 5,500 feet in a medium of water to satisfy state requirements.

None of the geophysical surveys were run to sufficient depth (>5,600 feet) to contribute data of value.

FLUID GEOCHEMISTRY

On April 22, 1981 Lanipuna #1 was unloaded with air and four samples of fluid collected from the blooie line. Original reports of laboratory analyses with an outline of the hole condition and test procedures are in Appendix F. Included also is an analysis of the drilling water which was previously used also at Ashida #1. Other drilling and test data indicate that the fluid produced most likely came from a permeable zone at 4,000 feet, where the temperature is about 320°F (160°C).

An increase in salinity from sample to sample during the test implies that the hole was being purged of a mixture of saline formation and dilute drilling fluids, and the final sample does not necessarily represent uncontaminated formation fluid. The major species in the final sample compare with sea water as follows (concentrations in mg/l):

	Final test sample 4-22-81	Sea-water
Na	8,578	10,500
Ca	1,530	400
K	8.1	380
Mg	0.5	1,350
Cl	15,700	19,000
SO_4	112	2,700
HCO_3	92	142
SiO_2	52.9	6.4
B	5.36	4.6

The final test sample is quite different from water produced by HGP-A and water bailed from Ashida #1 at 804 to 844 ft. HGP-A water has reportedly been of variable composition, increasing in salinity apparently due to sea water intrusion into the reservoir. Samples from HGP-A in 1976 showed about 1,000 mg/l Cl throughout the production zone, but in more recent years this has increased by as much as several hundred percent, varying with depth. The HGP-A fluids also have a characteristic high-temperature geothermal signature with factors such as low Mg and Ca, a low ratio Na/K (about 7 by weight) and high SiO_2 (about 400 mg/l). These also have varied somewhat with the supposed sea water intrusion.

The Lanipuna fluid lacks high-temperature characteristics except for the low Mg. Its composition is rather unusual, but detailed analysis would very probably show that it is the result of low to moderate-temperature reactions between sea water and basalt, followed by dilution with about 15% to 20% of the dilute drilling water. Experiments have shown that at low temperatures basalts tend to release Ca, Mg and SiO_2 to sea water, while retaining or extracting K, which may be captured by clay minerals formed

from feldspars. The loss of Mg in this case may be explained by formation of sepiolitic clay or the mineral chlorite, which develops at about 150°C. SiO_2 in the fluid corresponds to the solubility of quartz at about 104°C. Correction for dilution by 20% drilling water with 25 mg/l SiO_2 produces no significant change in this estimate. Free quartz was observed in cuttings from the 4,000 foot zone, although in this temperature range the greater solubility of chalcedony often is the control over dissolved SiO_2. In any case, the fluid produced by the test almost certainly did not come from a high-temperature reservoir.

TEMPERATURE REGIME

GeothermEx, Inc. conducted 22 surveys during breaks in the drilling of Lanipuna #1 (Appendix C). In addition, Water Resources International, Inc. ran 4 temperature surveys within the upper half of the open hole following pump tests (Appendix D). Together these surveys have helped to delineate formation permeability and to approximate true formation temperature (figure 5).

From a depth of 2,200 feet to 4,800 feet the gradient averages 4-5°F/100 feet. There are two permeable zones which are indicated by temperature reversals. One, at 3,500 feet, may extend below the casing shoe. The other, more permeable zone is at 4,000 feet. It took most, if not all, of the injected fluid in pump tests. The highest temperature recorded at 4,000 feet is 295°F. The equilibrium formation temperature is probably less than 330°F, well below a minimum production temperature of 400°F.

At a depth of 4,800 feet, the temperature gradient increased to 15-20°F/100 feet. This gradient is maintained to a depth of 5,700 feet. The maximum temperature recorded in the interval is 456°F at 5,700 feet. Equilibrim formation temperature may be as high as 500°F. From 4,800 feet to 5,700 feet there are no permeable horizons. The gradient is conductive.

At a depth of 5,800 feet the gradient "rolls over" and approaches isothermal conditions. From 6,100 feet to 6,200 feet, the gradient is negative and indicates a permeable horizon which took some quantity of mud drilling fluid.

From a depth of 6,300 to total depth at 8,389 feet, the gradient is conductive, but variable, ranging from 10°F/100 feet to over 40°F/100 feet. The maximum recorded temperature was 686°F at 8,389 feet. This temperature merely represents the limited range of the Kuster instrument (127° to 686°F). The equilibrium formation temperature at total depth probably exceeds 700°F.

To summarize, the Ashida #1 temperature profile represents a conductive regime. Because of its proximity to the east rift zone, information derived from the well may be used with confidence as background data in working with the more complex environments of production wells.

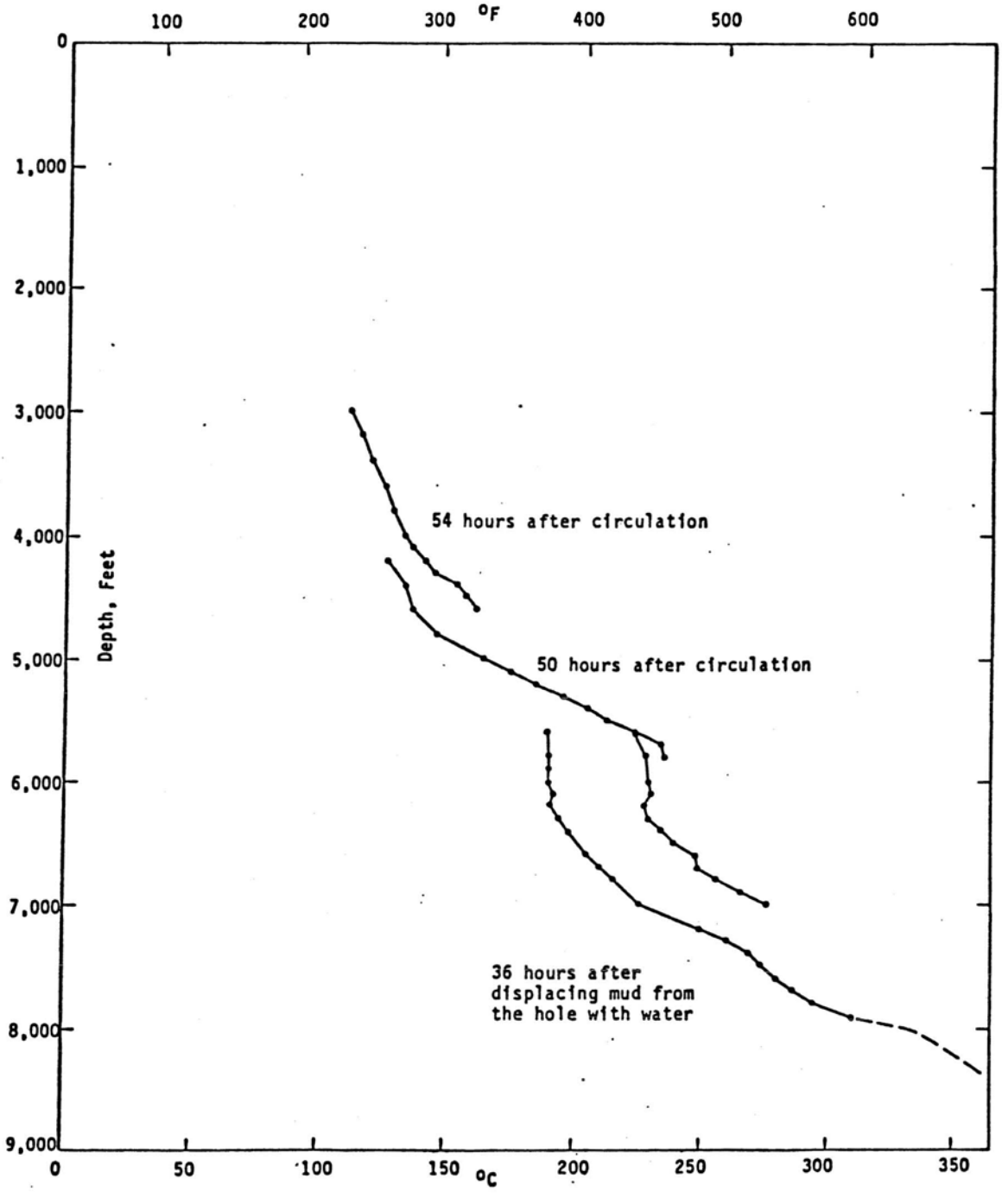

FIGURE 5. Lanipuna #1, Temperature Surveys

REFERENCES

Ellis, A. J. and Mahon, W. A. J., 1977, Chemistry and Geothermal Systems, Acedemic Press, New York, 392 pp.

Grant, Malcolm A., 1979, Interpretation of downhole measurements in geothermal wells; Report #88, Applied Mathematics Division, Dept. of Scientific and Industrial Research, Wellington, New Zealand, 45 p.

Hoagland, James R., and Elders, Wilfred A., 1978, Hydrothermal mineralogy and isotopic geochemistry in the Cerro Prieto geothermal field, Mexico. I. Hydrothermal mineral zonation in G.R.C. Transactions, vol. 2, July 1978, p. 283-286.

Kristomannsdottir, Hrefna, 1975, Hydrothermal alteration of basaltic rocks in Icelandic geothermal areas in Second U.N. symposium on the development and use of geothermal resources: San Francisco Proceedings, p. 441-445.

APPENDIX A

Lanipuna #1, Lithologic Description of Drill Cuttings

LITHOLOGIC LOG

Lanipuna #1

Depth Interval, feet	
	Completion Date: May 26, 1981
1,170-1,190	100% BASALT, Type A. Description: Highly vesicular (≤2 mm) lava with scattered phenocrysts of olivine (≤1 mm, green, equant, anhedral) and plagioclase (≤.5 mm, colorless, tabular, subhedral) within a red-brown to black aphanitic matrix. Alteration: A pale blue material lines most vesicles and fills a few of them. Most of the groundmass mafics are oxidized to a red color, and some olivine phenocrysts are rimmed by red-brown iddingsite.
1,190-1,200	100% BASALT, Type A. Description: As above, with a few clasts of porous, brecciated flow. Alteration: Pale blue to green substance lines vesicles and fills a few of them. Pyrite cubes also line a few vesicles. White silica coats a very few clasts. Olivine phenocrysts are altered to iddingsite.
1,200-1,230	100% BASALT, Type A. Description: As above. Alteration: As above, but some scattered vesicles are filled with botryoidal to tabular pale green material.
1,230-1,240	100% BASALT, Type A. Description: Highly vesicular (.1-3 mm) lava with scattered phenocrysts of olivine (≤2.5 mm, green, equant, subhedral to anhedral) and plagioclase (≤3 mm, colorless, tabular, subhedral to anhedral) within dark red-brown to gray-brown aphanitic groundmass. Alteration: Pale blue substance (chlorophaeite) lines most vesicles. There are traces of red hydrous iron oxide coating clasts.
1,240-1,250	No sample.
1,250-1,300	100% BASALT, Type A, as above.

LITHOLOGIC LOG

Lanipuna #1 (continued)

1,300-1,320 100% BASALT, Type A.
Description: Highly vesicular (.1-3 mm) lava with scattered phenocrysts of olivine (≤2 mm, green, equant, subhedral to anhedral) and plagioclase (≤1 mm, colorless, tabular, subhedral) within a gray to black, glassy groundmass.
Alteration: Pale blue to green chlorophaeite lines vesicles.

1,320-1,340 50% BASALT, Type A, as above.
50% BASALT, Type B.
Description: Nonvesicular lava with scattered phenocrysts of olivine (≤1 mm, green, equant, anhedral to subhedral) and plagioclase (≤.5 mm, colorless, tabular, subhedral) within a groundmass of feldspar laths and glassy interstitial material.
Alteration: None.

1,340-1,350 20% BASALT, Type A, as above.
80% BASALT, Type B, as above.

1,350-1,360 45% BASALT, Type A, as above.
45% BASALT, Type B, as above.
10% BASALT, Type C.
Description: Vesicular (.1-1 mm) vitrophyre with rare phenocrysts of olivine (≤.2 mm, green, equant, anhedral) in a matrix of black glass.
Alteration: None.

1,360-1,370 30% BASALT, Type A, as above.
60% BASALT, Type B, as above.
10% BASALT, Type C, as above.

1,370-1,390 10% BASALT, Type A, as above.
90% BASALT, Type B, as above.

1,390-1,400 60% BASALT, Type A, as above.
35% BASALT, Type B, as above.
5% BASALT, Type C, as above.

1,400-1,420 100% BASALT, Type A, as above.

1,420-1,430 80% BASALT, Type A, as above.
15% BASALT, Type B.
Description: As above.

LITHOLOGIC LOG

Lanipuna #1 (continued)

Alteration: Trace amounts of white, botryoidal silica.
5% BASALT, Type C, as above.

1,430-1,450 100% BASALT, Type A.
Description: As above.
Alteration: Pale blue chlorophaeite lines vesicles. Patches of white mottled groundmass material indicate some incipient alteration.

1,450-1,530 100% BASALT, Type A.
Description: Vesicular (.1-1 mm) lava with scattered phenocrysts of olivine (≤2 mm, green, equant, anhedral) and plagioclase (≤.5 mm, colorless, tabular, subhedral) within a glassy, black aphanitic groundmass.
Alteration: Soft, pale blue chlorophaeite lines vesicles. Some white patches of groundmass material indicate incipient alteration.

1,530-1,590 No samples collected.

1,590-1,600 100% BASALT, Type B.
Description: A dense lava with rare vesicles (<.5 mm) and scattered phenocrysts of olivine (≤1 mm, green, equant, anhedral) and plagioclase (≤2 mm, colorless, tabular, subhedral) in a groundmass of feldspar laths and glassy interstitial material.
Alteration: Patches of groundmass material are white indicating incipient alteration.

1,600-1,620 60% BASALT, Type B, as above.
40% BASALT, Type A, as above.

1,620-1,650 50% BASALT, Type B.
Description: As above.
Alteration: Olivine phenocrysts are altered to brown iddingsite. Some apparent argillic alteration of groundmass feldspars.
50% BASALT, Type A.
Description: As above.
Alteration: All vesicles (≤1 mm) are lined with blue chlorophaeite. Some are filled with a soft, blue-green substance. There are traces of pyrite lining vesicles and calcite scales.

LITHOLOGIC LOG

Lanipuna #1 (continued)

1,650-1,660
40% BASALT, Type B, as above.
40% BASALT, Type A, as above.
20% BASALT, Type C.
Description: A vesicular vitrophyre with no apparent phenocrysts. Some clasts are brecciated.
Alteration: Intense alteration of clasts to a chalky gray to red color. Vesicles are lined in pale blue-gray or red.

1,660-1,670
100% BASALT, Type C.
Description: Slightly vesicular to highly vesicular vitrophyre with scattered phenocrysts of olivine (≤1 mm, green, equant to elongate, anhedral to subhedral) and plagioclase (≤1 mm, colorless, tabular, subhedral) within a glassy groundmass. Some clasts are brecciated.
Alteration: Chlorophaeite lines the vesicles of the few (<10%) fresh clasts. Most clasts are highly altered with olivine altered to red-brown iddingsite and plagioclase to a white and green substance. Most of the glass is altered to a white or pale green.

1,670-1,680
50% CLAY, red brown, silty.
50% BASALT, Type C.
Description: As above.
Alteration: As above, but some clasts are covered with disseminated pyrite.

1,680-1,690
50% CLAY, red-brown, silty.
50% BASALT, Type C.
Description: As above.
Alteration: Approximately 20% of the clasts have chlorophaeite-lined vesicles and no other apparent alteration. The bulk of the sample has undergone variable, moderate to intense argillic alteration.

1,690-1,700
20% CLAY, red-brown, silty.
40% BASALT, Type A.
Description: Highly vesicular (.1-3 mm) lava with scattered phenocrysts of olivine and plagioclase within a glassy, aphanitic groundmass.
Alteration: Vesicles are lined with blue chlorophaeite. Patches of groundmass are altered to a light green.
40% BASALT, Type B, as above.

LITHOLOGIC LOG

Lanipuna #1 (continued)

1,700-1,720 50% CLAY, as above.
25% BASALT, Type A, as above.
25% BASALT, Type C, as above.

1,720-1,740 15% CLAY, as above.
85% BASALT, Type C.
Description: Slightly vesicular to highly vesicular (.1-4 mm) vitrophyre with scattered phenocrysts of olivine and plagioclase within black glass. Some brecciation.
Alteration: Approximately 10% of all clasts are only slightly altered with chlorophaeite lining vesicles, olivine altered to iddingsite and traces of pyrite. All other clasts have undergone moderate to intense alteration of glass to a white or green, friable substance and pyrite cubes have been replaced by hydrous iron oxide.

1,740-1,750 20% CLAY, as above.
80% BASALT, Type C.
Description: As above.
Alteration: 25% of all clasts are only slightly altered, as above. 75% of all clasts are more intensely altered, as above.

1,750-1,780 100% BASALT, Type C.
Description: Highly vesicular vitrophyre with rare phenocrysts of olivine and plagioclase in black glass.
Alteration: Chlorophaeite lines vesicles. Pyrite is partially altered to red hydrous iron oxide. Traces of botryoidal silica. Incipient alteration of glass is indicated by its dull luster.

1,780-1,820 100% BASALT, Type C.
Description: Dense to highly vesicular vitrophyre, as above.
Alteration: As above.

1,820-1,840 100% BASALT, Type C.
Description: Highly vesicular (.1-3 mm) vitrophyre with scattered phenocrysts of olivine ($\leq$1 mm, green, equant, subhedral to anhedral) and plagioclase ($\leq$1 mm, colorless, tabular, subhedral) within a black glassy groundmass.
Alteration: As above (1,750-1,780)

LITHOLOGIC LOG

Lanipuna #1 (continued)

1,840-1,860 100% BASALT, Type C.
Description: Slightly vesicular to highly vesicular (.1-2 mm) vitrophyre with phenocrysts, as above.
Alteration: Chlorophaeite lines vesicles. Some incipient alteration of glass to a dull gray-green.

1,860-1,870 100% BASALT, Type C.
Description: As above.
Alteration: As above, plus traces of botryoidal silica and traces of hydrous iron oxide.

1,870-1,890 100% BASALT, Type C.
Description: Vesicular (.1-.5 mm) vitrophyre with phenocrysts of olivine and plagioclase.
Alteration: Chlorophaeite lines vesicules and is associated with pyrite. Botryoidal silica coats a few clasts and is associated with pyrite and red hydrous iron oxide. A soft green botryoidal mineral fills a few vesicles.

1,890-1,900 No sample.

1,900-1,910 100% BASALT, Type C, as above.

1,910-1,920 50% BASALT, Type C, as above.
50% BASALT, Type B.
Description: Slightly vesicular (.1-.5 mm) to non-vesicular fractured rock with scattered phenocrysts of olivine ($\leq$.5 mm) and plagioclase ($\leq$.25 mm) within a groundmass of abundant feldspar laths and interstitial glassy material.
Alteration: Vesicles are lined with pale blue chlorophaeite. Groundmass feldspars are slightly altered to a frosty white color. Interstitial material is slightly green, indicating some alteration to chlorite. On fracture surfaces the rock is altered to a waxy green or blue substance and is associated with pyrite. Much of the pyrite is oxidized, staining the rock orange along the fractures.

1,920-1,950 100% BASALT, Type B, as above.

LITHOLOGIC LOG

Lanipuna #1 (continued)

1,950-1,970 50% BASALT, Type B, as above.
50% BASALT, Type C.
Description: Highly vesicular (≤.5 mm), fractured vitrophyre with scattered phenocrysts of olivine (≤1 mm) and plagioclase (≤1 mm) within black glass.
Alteration: Chlorophaeite lines vesicles. Traces of pyrite on fracture surfaces.

1,970-1,990 100% BASALT, Type C.
Description: As above.
Alteration: Chlorophaeite lines vesicles. A few vesicles are filled with a soft green substance. Pyrite and chlorophaeite(?) cover fracture surfaces. Some pyrite is altered to red hydrous iron oxide. A few clasts show incipient alteration of glass around vesicles to a gray color.

1,990-2,010 100% BASALT, Type C.
Description: As above, but vesicles up to 2 mm wide.
Alteration: As above.

2,010-2,060 80% BASALT, Type C, as above.
20% BASALT, Type B.
Description: Slightly vesicular (.1-1 mm) fractured rock with phenocrysts of olivine (≤1 mm) and plagioclase (≤1 mm) within a groundmass of abundant feldspar laths and glassy interstitial material.
Alteration: Chlorophaeite and pyrite line vesicles and fractures. Incipient alteration of groundmass constituents is indicated by frosty, white feldspar and the green tint of the interstitial material. Some oxidation of pyrite has resulted in patches of orange stain.

2,060-2,080 50% BASALT, Type C, as above.
50% BASALT, Type B, as above.

2,080-2,100 10% CLAY, gray.
45% BASALT, Type C, as above.
45% BASALT, Type B.
Description: As above.
Alteration: As above, but no oxidation of pyrite to red iron oxide.

LITHOLOGIC LOG

Lanipuna #1 (continued)

2,100-2,140 100% BASALT, Type B.
Description: Vesicular (≤.5 mm) rock with phenocrysts of olivine and plagioclase within a matrix of abundant feldspar laths and black glassy interstitial material.
Alteration: Green to blue chlorophaeite lines vesicles and is associated with pyrite. Groundmass constituents have undergone variable slight argillic alteration. Feldspar laths are white and altered glass is green.

2,140-2,150 90% BASALT, Type B, as above.
10% BASALT, Type C.
Description: Highly vesicular (.1-3 mm) vitrophyre with phenocrysts of olivine (≤1 mm, green, equant, anhedral) and plagioclase (≤1 mm), colorless, tabular, subhedral) within black glass.
Alteration: Pale blue to green chlorophaeite and pyrite line vesicles. Trace amounts of waxy green substance filling vesicles.

2,150-2,160 60% BASALT, Type B, as above.
40% BASALT, Type C.
Description: As above, but many clasts are rounded and they may be clastic.
Alteration: As above.

2,160-2,170 20% BASALT, Type B, as above.
70% BASALT, Type C, as above.
10% CLAY, gray.

2,170-2,190 60% BASALT, Type C, as above.
40% CLAY, gray.

2,190-2,210 100% BASALT, Type C (clastic?)
Description: As above.
Alteration: Clasts are rounded and most have lost their vitreous luster, indicating incipient argillic alteration. Pyrite and green chlorophaeite(?) are abundant.

2,210-2,220 100% BASALT, Type C.
Description: As above.
Alteration: 20% of all clasts are fresh, angular vitrophyre. 80% are dull, rounded clasts.

LITHOLOGIC LOG

Lanipuna #1 (continued)

2,220-2,240 20% BASALT, Type C.
Description: As above.
Alteration: Chlorophaeite and pyrite line vesicles. The glass is fresh.
80% BASALT, Type B.
Description: Highly vesicular (.1-1 mm) rock with phenocrysts of olivine and plagioclase within a matrix of feldspar laths and glassy interstitial material.
Alteration: Chlorophaeite and pyrite line vesicles. Variable argillic alteration of groundmass feldspars.

2,240-2,300 100% BASALT, Type C.
Description: Vesicular (.1-4 mm) vitrophyre with scattered phenocrysts of olivine and plagioclase.
Alteration: Blue chlorophaeite lines vesicles. A few vesicles are partially filled with a soft green substance. Traces of pyrite. Much of the glass has lost its luster, indicating incipient argillic alteration.

2,300-2,330 50% BASALT, Type C, as above.
50% BASALT, Type C^1.
Description: Highly vesicular (.1-5 mm) vitrophyre with phenocrysts of olivine and plagioclase within a sugary textured groundmass.
Alteration: Pale blue chlorophaeite coats vesicles. Abundant pyrite disseminations. A few vesicles are partially filled with a tabular to platey, green mineral.

2,330-2,350 60% BASALT, Type C, as above.
40% BASALT, Type C^1.
Description: As above, with some brecciation.
Alteration: As above, plus blue chalcedony in veins.

2,350-2,370 40% BASALT, Type C, as above.
60% GRAVEL.
Description: 2-5 mm, subround; composed of vesicular vitrophyre.
Alteration: Clasts are covered with pale green material and pyrite disseminations.

2,370-2,390 No sample.

LITHOLOGIC LOG

Lanipuna #1 (continued)

2,390-2,400 100% GRAVEL.
Description: 2-10 mm, subround, composed of slightly vesicular to vesicular Types C and D basalts.
Alteration: Clasts are covered with pale green material and pyrite disseminations.

2,400-2,430 40% BASALT, Type C, as above.
60% GRAVEL, as above.

2,430-2,440 100% BASALT, Type C.
Description: Vesicular (.1-1 mm) vitrophyre with phenocrysts of olivine and plagioclase within black glass.
Alteration: Chlorophaeite and pyrite line vesicles.

2,440-2,470 50% BASALT, Type C.
Description: Dense to vesicular ($\leq$1 mm) vitrophyre with scattered phenocrysts of olivine and plagioclase.
Alteration: Chlorophaeite lines vesicles. Abundant pyrite in vesicles, trace of free anhydrite.
40% GRAVEL, as above.
10% CLAY.

2,470-2,480 30% BASALT, Type C, as above.
70% GRAVEL, as above.

2,480-2,500 100% BASALT, Type C.
Description: Slightly to highly vesicular (.1-1 mm) dull brown vitrophyre with phenocrysts of olivine ($\leq$1 mm, green, equant) and plagioclase ($\leq$1.5 mm, colorless, tabular).
Alteration: Pale green or blue chlorophaeite lines vesicles. Pyrite cubes lines vesicules. A small (<.15%) percentage of vesicles are partially filled with a pale green soft, botryoidal zeolite(?). Dull luster of glass indicates incipient alteration.

2,500-2,520 100% BASALT, Type C.
Description: As above.
Alteration: As above, plus trace amounts of loose, white silica.

LITHOLOGIC LOG

Lanipuna #1 (continued)

2,520-2,530 100% BASALT, Type C.
Description: As above.
Alteration: Chlorophaeite and pyrite line vesicles. Pale green botryoidal zeolite(?) and fibrous white zeolite partially fill 10% of all vesicles.

2,530-2,540 100% BASALT, Type C.
Description: As above.
Alteration: As above, but no fibrous, white zeolite.

2,540-2,550 50% BASALT, Type C, as above.
50% BASALT, Type B.
Description: Vesicular (.1-.5 mm) rock with phenocrysts of olivine and plagioclase within a matrix of abundant feldspar laths and glassy interstitial material.
Alteration: Green chlorophaeite and pyrite cubes line vesicles. About 10% of all vesicles are partially filled with a soft green, botryoidal zeolite. Patchy incipient alteration of groundmass feldspars.

2,550-2,580 50% BASALT, Type C.
Description: Vesicular (.1-2 mm) vitrophyre with phenocrysts of olivine and plagioclase.
Alteration: Pale blue to green chlorophaeite and pyrite cubes line vesicles. One vein of chalcedony.
50% GRAVEL.
Description: 4-6 mm, round; composed of altered Type C vesicular vitrophyre.
Alteration: Green and blue chlorophaeite and pyrite coat clasts. Vesicles are partially filled with botryoidal zeolite.

2,580-2,600 25% BASALT, Type C, as above, but no silica.
60% BASALT, Type B, as above.
15% GRAVEL, as above.

2,600-2,620 60% BASALT, Type C, as above.
40% BASALT, Type B, as above.

LITHOLOGIC LOG

Lanipuna #1 (continued)

2,620-2,650 80% BASALT, Type B.
Description: Slightly vesicular (.1-1 mm) rock with phenocrysts of olivine and plagioclase within a matrix of feldspar laths and aphanitic interstitial material.
Alteration: Most clasts are rounded, dull green and friable. White fibrous to botryoidal zeolite is abundant.
20% BASALT, Type C, as above.

2,650-2,680 80% BASALT, Type B.
Description: Vesicular ($\leq$.5 mm) rock with scattered phenocrysts of olivine and plagioclase set in a groundmass of feldspar laths and glassy interstitial material.
Alteration: Traces of pyrite and white chalcedony are in fractures. White fibrous zeolite is abundant lining vesicles. Many vesicles are lined with a very soft gray material. Groundmass constituents are slightly altered with white feldspars and a green cast to interstitial material.
20% CLAY, gray.

2,680-2,690 80% BASALT, Type B.
Description: As above, but only slightly vesicular.
Alteration: As above.
20% CLAY, gray.

2,690-2,700 40% BASALT, Type B, as above.
40% BASALT, Type C.
Description: Slightly vesicular to vesicular (.1-1 mm) vitrophyre with abundant plagioclase phenocrysts ($\leq$1 mm), colorless to white, tabular, subhedral) and lesser amounts of olivine.
Alteration: Variable alteration of feldspars marked by the change from colorless to white. Abundant pyrite cubes disseminated in vitrophyre.
20% CLAY, gray.

2,700-2,710 75% BASALT, Type B, as above.
10% BASALT, Type C, as above.
15% CLAY, gray.

LITHOLOGIC LOG

Lanipuna #1 (continued)

2,710-2,750 100% BASALT, Type B.
Description: Slightly vesicular (.1-1 mm) rock with phenocrysts of green olivine, black pyroxene and colorless plagioclase set in a groundmass of abundant feldspar laths and glassy interstitial material.
Alteration: Fibrous zeolite in most vesicles. Trace amounts of anhydrite, pyrite and chalcedony on fracture surface. Some partial filling of vesicles with a soft, waxy, green substance. Groundmass constituents have undergone variable negligible to moderate alteration. Most altered clasts contain white groundmass feldspars and interstitial material is altered to a pale green. Many of the clasts, especially the more altered ones, are rounded.

2,750-2,780 100% BASALT, Type B.
Description: Slightly vesicular (.1-2 mm) rock with scattered phenocrysts of olivine (≤1 mm, green, equant, anhedral), pyroxene (≤1 mm, black, equant to tabular, anhedral to subhedral) and plagioclase (≤1 mm, colorless, tabular) set in a groundmass of abundant feldspar laths (≤.1 mm) and glassy interstitial material.
Alteration: Most vesicles are partially to completely filled with a soft, waxy, dark green substance. Some vesicles are lined with the dark green material and filled with fibrous zeolite. Pyrite, chalcedony and anhydrite are present in trace amounts coating clast surfaces. Groundmass constituents have undergone variable, slight to moderate alteration. Moderately altered clasts have white groundmass feldspars and pale green interstitial material.

2,780-2,790 70% BASALT, Type B, as above.
30% CLAY, gray.

2,790-2,850 75% BASALT, Type B.
Description: Slightly vesicular (≤1 mm) to non-vesicular rock with scattered phenocrysts of green olivine, black pyroxene and colorless plagioclase set in a groundmass of feldspar lath and intersertal pyroxene and glass.

LITHOLOGIC LOG

Lanipuna #1 (continued)

Alteration: All vesicles are either partially filled with white fibrous zeolite or completed filled by green, waxy substance. Pyrite lines vesicles with zeolite. Platey anhydrite clusters coat clasts or are loose crystals. Groundmass constituents have undergone argillic alteration and some chloritization to a pale green color.
25% CLAY, gray.

2,850-2,860 100% BASALT, Type B, as above.

2,860-2,890 100% BASALT, Type C.
Description: Nonvesicular black vitrophyre with scattered phenocrysts of olivine (≤1 mm, yellow-green, equant, anhedral) and plagioclase (≤.5 mm, colorless, tabular).
Alteration: Abundant pyrite disseminations. Traces of anhydrite coating clasts. Clasts break easily along fractures. Fractured surfaces are coated with a soft, dark, waxy substance.

2,890-2,900 75% BASALT, Type C, as above.
25% BASALT, Type B.
Description: Nonvesicular rock with phenocrysts of plagioclase and olivine set in a groundmass of abundant feldspar laths and glassy interstitial material.
Alteration: Patchy incipient alteration of groundmass feldspars is indicated by their white color. Traces of pyrite as disseminations. Traces of zeolite and anhydrite in rare vesicular clasts may be uphole contaminants.

2,900-2,920 100% BASALT, Type B, as above.

2,920-2,940 100% BASALT, Type B.
Description: Slightly vesicular (≤.5 mm) rock with widely scattered phenocrysts of pyroxene (≤1 mm, black, prismatic), olivine (≤1 mm, green, equant) and plagioclase (≤.5 mm, colorless, tabular) set in a groundmass of abundant feldspar laths and glassy interstitial material.

LITHOLOGIC LOG

Lanipuna #1 (continued)

Alteration: Patchy argillic alteration of groundmass feldspars and glass. Fibrous white zeolite, colorless anhydrite and pyrite fill some vesicles (<10%). Most vesicles (about 80%) are completely filled with a soft, dark green, waxy substance.

2,940-2,970 100% BASALT, Type B.
Description: As above, but vesicles are ≤2 mm.
Alteration: 80% of all clasts have undergone extensive argillic alteration and possibly chloritization. These clasts are pale gray-green and "dirty." 20% of all clasts are black, glassy and apparently unaltered. Fibrous zeolite, anhydrite and pyrite are present in minor amounts. 80% of all vesicles are filled with a dark green substance.

2,970-2,980 100% BASALT, Type B.
Description: As above.
Alteration: As above, but no zeolite observed.

2,980-3,000 70% BASALT, Type B, as above.
30% BASALT, Type C.
Description: Nonvesicular vitrophyre with scattered pyroxene and plagioclase phenocrysts.
Alteration: A waxy green substance coasts fracture surfaces. Traces of pyrite and anhydrite on fracture surfaces.

3,000-3,010 50% BASALT, Type B, as above.
50% BASALT, Type C, as above.

3,010-3,030 100% BASALT, Type C.
Description: Nonvesicular vitrophyre with abundant to scarce phenocrysts of olivine, pyroxene and plagioclase.
Alteration: A few clasts hvae undergone extensive argillic alteration. More than 90% have undergone slight or negligible alteration. Fracture surfaces are coated with a soft green substance.

3,030-3,070 100% BASALT, Type B.
Description: Nonvesicular rock with scattered phenocrysts of olivine, pyroxene and plagioclase set in a matrix of feldspar laths and glassy interstitial material.

Alteration: Patchy alteration of feldspars from colorless to white, traces of anhydrite(?) vein material.

3,070-3,090 100% BASALT, Type B.
Description: As above.
Alteration: Alteration of feldspars is more pervasive. Traces of calcite, anhydrite and pyrite veins.

3,090-3,100 100% BASALT, Type B.
Description: As above.
Alteration: Patchy alteration of feldspar. Minor pyrite.

3,100-3,110 100% BASALT, Type B.
Description: Nonvesicular rock with scattered phenocrysts of olivine, pyroxene and plagioclase set in a groundmass of feldspar laths and intersertal pyroxene and glass.
Alteration: Patchy alteration of feldspar and groundmass material to chalky white material.

3,110-3,140 100% BASALT, Type B.
Description: As above.
Alteration: Patchy argillic alteration of feldspars. Scattered pyrite cubes. Soft green or blue waxy material coats fracture surfaces.

3,140-3,150 90% BASALT, Type B.
Description: As above.
Alteration: Patchy, slight to intense argillic alteration--a few clasts are white and friable. Scattered pyrite cubes. Soft green waxy material coats fracture surfaces.
10% CLAY, gray.

3,150-3,170 75% BASALT, Type B.
Description: As above.
Alteration: Pervasive, moderate to intense alteration. 10% of all clasts are white and friable. Pyrite cubes and waxy, green material coat fracture surfaces.
25% CLAY, gray.

LITHOLOGIC LOG

Lanipuna #1 (continued)

3,170-3,180 85% BASALT, Type B.
Description: As above.
Alteration: As above plus anhydrite on fracture surfaces.
15% CLAY, gray.

3,180-3,190 80% BASALT, Type B.
Description: As above.
Alteration: Pervasive argillic alteration of feldspars. Abundant free anhydrite(?) crystals. Traces of pyrite.
20% CLAY, gray.

3,190-3,200 50% BASALT, Type B, as above.
50% CLAY, gray.

3,200-3,220 100% BASALT, Type B.
Description: As above, but slightly to highly vesicular (.1-2 mm).
Alteration: Patchy, moderate to intense argillic alteration. Trace amounts of anhydrite and pyrite. 25% of all clasts are rounded and have undergone intense argillic alteration. Vesicles are filled with a soft dark green, waxy substance. A few contained quartz crystals. Trace amounts of free anhydrite crystals.

3,220-3,230 75% BASALT, Type B.
Description: Nonvesicular rock with phenocrysts of olivine, pyroxene and plagioclase set in a groundmass of feldspar laths, pyroxene and glass.
Alteration: Patchy argillic alteration. Traces of pyrite and anhydrite.
25% BASALT, Type C.
Description: Vesicular ($\leq$.1 mm) vitrophyre with scattered phenocrysts of olivine, pyroxene and feldspar.
Alteration: Vesicles are filled with a soft, dark green, waxy substance.

3,230-3,250 100% BASALT, Type B.
Description: As above but slightly vesicular (.1-1 mm).
Alteration: Pervasive argillic alteration of feldspars. Vesicles are lined with quartz and pyrite cubes.

LITHOLOGIC LOG

Lanipuna #1 (continued)

3,250-3,260 100% BASALT, Type B.
Description: Nonvesicular rock with phenocrysts of green olivine and black pyroxene (typically intergrown) and colorless plagioclase set in a groundmass of feldspar, pyroxene and glass.
Alteration: Patchy argillic alteration of feldspars. trace amounts of pyrite.

3,260-3,270 100% BASALT, Type B.
Description: As above.
Alteration: Patchy argillic alteration of feldspars. Abundant pyrite and green waxy material coating fracture surfaces.

3,270-3,280 100% BASALT, Type B.
Description: Nonvesicular rock with scattered phenocrysts of pyroxene, plagioclase and olivine set in a groundmass of feldspar laths, pyroxene and glass.
Alteration: 10% of all clasts are angular, hard, black and slightly altered. 90% of all clasts are rounded, soft, green and extremely altered. Pyrite is present in the more altered clasts.

3,280-3,290 60% BASALT, Type B.
Description: As above, but some breccia.
Alteration: Intense alteration of all clasts to a soft, green substance. Brecciated clasts are cut by abundant veins of pyrite, anhydrite and/or calcite.
20% BASALT, Type C.
Description: Slightly vesicular (.4 mm) vitrophyre with phenocrysts of olivine, pyroxene and plagioclase.
Alteration: Incipient alteration of glass. Vesicles filled with green material.
20% CLAY, gray.

3,290-3,300 50% CLAY, gray.
40% BASALT, Type B, breccia, as above.
10% BASALT, Type C, as above.

3,300-3,310 70% BASALT, Type B, breccia.
Alteration: As above.
30% BASALT, Type C, as above.

LITHOLOGIC LOG

Lanipuna #1 (continued)

3,310-3,330 50% BASALT, Type B, breccia, as above.
50% BASALT, Type C, some breccia.
Description: As above.
Alteration: Vesicles are filled with a soft, pale green substance. A few clasts are cut by veins of pyrite. Brecciated clasts are cemented by pale green material.

3,330-3,360 100% BASALT, Type C, some breccia.
Description: Slightly vesicular (.1-.5 mm) vitrophyre with phenocrysts of olivine, plagioclase and pyroxene.
Alteration: Brecciated glass is cemented with soft pale green material. Vesicles are filled with pale green material. Abundant veins of pyrite with lesser amounts of quartz and calcite.

3,360-3,370 50% BASALT, Type C.
Description: Slightly vesicular (.1-.4 mm) to vesicular vitrophyre with phenocrysts of pyroxene, olivine and plagioclase.
Alteration: Pale green material and pyrite fill most vesicles. Abundant quartz vein material.
50% BASALT, Type B.
Description: Nonvesicular rock with phenocrysts of olivine, pyroxene and plagioclase set in a groundmass of feldspar, pyroxene and glass.
Alteration: Groundmass feldspars are altered white. Fractures contain pyrite and quartz.

3,370-3,380 75% BASALT, Type C, as above.
25% BASALT, Type B, as above.

3,380-3,390 80% BASALT, Type C, as above, with some breccia.
20% BASALT, Type B, as above.

3,390-3,410 80% BASALT, Type B.
Description: A nonvesicular rock with scattered phenocrysts of pyroxene, olivine and plagioclase set in a groundmass of feldspar laths, pyroxene and glass.
Alteration: Feldspar laths are altered white. Some soft, dark green substance coats fracture surfaces. Traces of pyrite.
20% BASALT, Type C, as above.

LITHOLOGIC LOG

Lanipuna #1 (continued)

3,410-3,420	100% BASALT, Type B. Description: As above. Alteration: Patchy, slight to moderate alteration of groundmass feldspar. Traces of pyrite on fracture surfaces.
3,420-3,430	50% BASALT, Type B, as above. 50% BASALT, Type C, as above.
3,430-3,450	40% ALTERED VOLCANIC ROCK. Description: Clasts of soft green friable material with abundant pyrite and quartz veins. 20% BASALT, Type B, as above. 20% BASALT, Type C, as above. 20% CLAY, gray.
3,450-3,460	40% BASALT, Type C, as above. 30% BASALT, Type B, as above. 30% ALTERED VOLCANIC ROCK, as above.
3,460-3,470	50% BASALT, Type B, as above. 30% BASALT, Type C, as above. 20% ALTERED VOLCANIC ROCK, as above.
3,470-3,490	50% BASALT, Type B, as above. 40% BASALT, Type C. Description: Slightly vesicular to vesicular (.1-2 mm) vitrophyre. Alteration: Pyrite, quartz veins. Trace amounts of iron oxide stains. 10% ALTERED VOLCANIC ROCK, as above.
3,490-3,520	50% BASALT, Type B, as above. 30% BASALT, Type C. Description: As above. Alteration: As above, but no iron oxide. 20% ALTERED VOLCANIC ROCK, as above.
3,520-3,550	75% BASALT, Type B. Description: Nonvesicular rock with scattered phenocrysts of plagioclase, pyroxene and olivine set in a groundmass of feldspar laths and glassy interstitial material. Alteration: Slight to negligible alteration of groundmass feldspar. Traces of quartz. 25% CEMENT

LITHOLOGIC LOG

Lanipuna #1 (continued)

3,550-3,570 50% BASALT, Type B, as above.
25% ALTERED VOLCANIC ROCK, as above.
25% CEMENT.

3,570-3,590 80% BASALT, Type B.
Description: As above.
Alteraton: Half of the clasts have undergone slight or negligible groundmass alteration. The other half have undergone intense alteration. Groundmass feldspars are white and the clasts are soft and friable. Traces of free quartz.
20% CEMENT.

3,590-3,600 80% BASALT, Type B.
Description: As above.
Alteration: 80% of all clasts are only slightly altered. 20% are highly altered to a soft, friable material. Traces of free quartz.
20% CEMENT.

3,600-3,620 50% BASALT, Type B, as above.
50% CEMENT.

3,620-3,630 75% BASALT, Type B.
Description: As above.
Alteration: 60% of all clasts have undergone slight or no alteration. 40% of all clasts are highly altered. Feldspars are white, and the clasts are soft and friable. Veins of milky chalcedony and pyrite are numerous.
25% CEMENT.

3,630-3,650 85% BASALT, Type B.
Description: As above.
Alteration: Slight pervasive alteration of groundmass feldspars.
15% CEMENT.

3,650-3,670 100% BASALT, Type B.
Description: As above.
Alteration: Moderate to intense alteration of groundmass material. Many clasts are rounded, soft and friable. Feldspars are white and interstitial material is gray to gray-green.

LITHOLOGIC LOG

Lanipuna #1 (continued)

3,670-3,680 100% BASALT, Type B.
Description: As above.
Alteration: Intense and pervasive. Clasts are rounded, soft, friable and mottled pale gray-green and black. Traces of milky chalcedony.

3,680-3,690 80% ALTERED VOLCANIC ROCK.
Description: Rounded, soft, friable clasts of pale gray-green material. Traces of pyrite and chalcedony.
20% BASALT, Type B.
Description: As above.
Alteration: Slight alteration of groundmass feldspars. Traces of pyrite.

3,690-3,710 50% ALTERED VOLCANIC ROCK, as above.
50% BASALT, Type B.
Description: Slightly vesicular (.1-.4 mm) to non-vesicular rock with scattered phenocrysts of pyroxene (<1 mm, black, equant to elongate, subhedral) and plagioclase (≤.5 mm, colorless, tabular, subhedral) set in a groundmass of feldspar laths and gray, aphanitic interstitial material.
Alteration: Slight alteration of feldspars to a white color. Traces of pyrite, quartz and chalcedony. Vesicles are filled with soft, dark green material.

3,710-3,730 100% BASALT, Type B.
Description: As above.
Alteration: Moderate to intense. Moderately altered clasts are angular, hard, dusty and pale gray-green. Intensely altered clasts are round, soft, dusty, friable and gray-green. Abundant pyrite and quartz.

3,730-3,750 100% BASALT, Type B.
Description: As above.
Alteration: Moderate to intense. Predominantly intense alteration to rounded, soft clasts of dusty, gray-green material. Abundant pyrite.

LITHOLOGIC LOG

Lanipuna #1 (continued)

3,750-3,780 100% BASALT, Type B.
Description: As above.
Alteration: Moderate to intense alteration of groundmass material to soft, friable, white and gray-green substance. Vesicles are lined with quartz and pyrite. Trace amounts of a yellow translucent mineral lining vesicles with pyrite.

3,780-3,840 100% BASALT, Type B.
Description: Vesicular ($\leq$2 mm) rock with phenocrysts of pyroxene and plagioclase set in a matrix of feldspar laths and intergranular pyroxene.
Alteration: Moderate alteration of groundmass minerals to white and pale green. Patchy silicification. Vesicles are lined with quartz and there are veins of quartz. Traces of pyrite in vesicles.

3,840-3,870 100% BASALT, Type C.
Description: Nonvesicular, black vitrophyre with rare phenocrysts of plagioclase ($\leq$.5 mm) and pyroxene ($\leq$.5 mm).
Alteration: 50% of all clasts are not altered. The other half are altered to a pale green. Vein quartz and pyrite are abundant. There is some patchy silicification of vitrophyre.

3,870-3,880 75% BASALT, Type C, as above.
25% BASALT, Type B.
Description: As above.
Alteration: Moderate to intense alteration. Clasts are rounded, friable and pale green.

3,880-3,890 80% BASALT, Type B, as above.
20% BASALT, Type C, as above.

3,890-3,900 100% BASALT, Type B, as above.

3,900-3,910 75% BASALT, Type B.
Description: As above.
Alteration: Moderate alteration of groundmass constituents to soft friable material. Trace amounts of quartz and pyrite.
25% BASALT, Type C.
Description: Nonvesicular vitrophyre with phenocrysts of black pyroxene and colorless plagioclase.
Alteration: Slight devitrification.

LITHOLOGIC LOG

Lanipuna #1 (continued)

3,910-3,920 80% BASALT, Type D.
Description: Nonvesicular, holocrystalline rock with phenocrysts of pyroxene (≤3 mm, brown to black, equant, subhedral) and plagioclase (<1.5 mm, colorless, tabular) set in a groundmass of interlocking feldspar (≤.3 mm) and pyroxene (≤.3 mm).
Alteration: Slight alteration of feldspars from colorless to white. Trace amounts of quartz veins.
20% BASALT, Type C, as above.

3,920-3,930 40% BASALT, Type D, as above.
40% BASALT, Type B.
Description: As above.
Alteration: Moderate to intense alteration of all clasts. Trace amounts of quartz and pyrite.
20% BASALT, Type C, as above.

3,930-3,940 100% BASALT, Type B.
Description: As above, but nonvesicular.
Alteration: 75% of the clasts have undergone slight alteration of groundmass constituents. 25% of the clasts are intensely altered to black and white, friable material. Some of these clasts are slickensided. Trace amounts of quartz.

3,940-3,950 100% BASALT, Type B.
Description: As above.
Alteration: 50% of the clasts are moderately altered. 50% are intensely altered with abundant slickensides.

3,950-3,970 75% BASALT, Type B.
Description: As above.
Alteration: 70% of the clasts are slightly altered. 30% are moderately to intensely altered. Trace amounts of quartz and pyrite.
25% CEMENT.

3,970-3,980 70% BASALT, Type B, as above.
15% BASALT, Type C, as above.
15% CEMENT.

LITHOLOGIC LOG

Lanipuna #1 (continued)

3,980-4,000	85% BASALT, Type D. Description: As above. Alteration: 80% of the clasts have undergone slight or negligible alteration. 20% of the clasts are soft, black and white and friable. Many of these clasts are slickensided. There are trace amounts of quartz and pyrite. 15% CEMENT.
4,000-4,010	100% BASALT, Type D, as above.
4,010-4,040	90% BASALT, Type B. Description: As above. Alteration: Moderate to intense alteration with some slickensides. Abundant quartz. Trace amounts of pyrite. 10% CEMENT
4,040-4,050	No sample.
4,050-4,070	85% BASALT, Type B. Description: As above. Alteration: Predominantly slight to moderate alteration of groundmass constituents. Some intense alteration associated with slickensides. Abundant quartz. 15% CEMENT.
4,070-4,080	50% BASALT, Type D, as above. 40% BASALT, Type B, as above. 10% CEMENT Trace BASALT, Type C. Description: Black aphyric glass. Alteration: None.
4,080-4,090	50% BASALT, Type D. Description: As above. Alteration: 70% of the clasts have undergone slight or moderate alteration of the groundmass. 30% have undergone intense alteration to a friable material with abundant slickensides. Abundant quartz. 20% BASALT, Type B, as above.

LITHOLOGIC LOG

Lanipuna #1 (continued)

20% BASALT, Type C, as above.
Description: Slightly vesicular (.1-.5 mm) vitrophyre with scattered phenocrysts of pyroxene, olivine and plagioclase.
Alteration: Trace amounts of pyrite and soft green material filling vesicles and veins.
10% CEMENT.

4,090-4,100
45% BASALT, Type D, as above.
40% BASALT, Type B, as above.
15% BASALT, Type C, as above.

4,100-4,110
80% BASALT, Type B, as above.
18% BASALT, Type D, as above.
2% BASALT, Type C, as above.

4,110-4,140
100% BASALT, Type B.
Description: Nonvesicular rock with phenocrysts of pyroxene, olivine(?) and plagioclase set in a groundmass of feldspar laths and glassy interstitial material.
Alteration: 20% are unaltered. 60% of the clasts have undergone slight to moderate alteration of groundmass constituents. Feldspar laths are whte, and interstitial material is pale green. 20% of the clasts are highly altered to a predominantly white, friable material with slickensides. Trace amounts of quartz and pyrite.

4,140-4,150
50% BASALT, Type B.
Description: As above.
Alteration: Most feldspars are altered white. 10% of the clasts are completely altered to white friable material. Many are striated or have slickensides.
50% BASALT, Type D.
Description: As above.
Alteration: Similar to Type B alteration. Trace amounts of free quartz.

4,150-4,170
60% BASALT, Type B, as above.
25% BASALT, Type C, as above, but nonvesicular. Trace amounts of free quartz and calcite.
15% BASALT, Type D, as above.

LITHOLOGIC LOG

Lanipuna #1 (continued)

4,170-4,180 50% BASALT, Type B.
Description: As above, with some loosely consolidated breccia.
Alteration: Intense alteration. Most clasts are rounded, soft and friable. Feldspars are white and interstitial material is olive green. Trace amounts of quartz and calcite.
50% BASALT, Type C, as above.

4,180-4,190 60% BASALT, Type D.
Description: Nonvesicular, holocrystalline rock with phenocrysts of pyroxene ($\leq$1.5 mm) and plagioclase ($\leq$1 mm) grading into a groundmass of feldspar and pyroxene.
Alteration: Variable. Predominantly slight alteration of feldspars. Some clasts are intensely altered to white friable material with striated surfaces.
20% BASALT, Type B, as above.
20% BASALT, Type C, as above.

4,190-4,210 70% BASALT, Type D, as above.
30% BASALT, Type C.
Description: As above.
Alteration: Variable devitrification. Trace amounts of quartz veins.

4,210-4,220 80% BASALT, Type B.
Description: As above.
Alteration: Variable. Predominantly slight alteration of feldspars. 10-20% intense alteration of clasts to friable material.
20% BASALT, Type C, as above.

4,220-4,250 100% BASALT, Type B.
Description: As above.
Alteration: Slight to moderate alteration. All feldspars are white. 20% of all clasts are altered to friable material. Traces of quartz, pyrite and calcite.

LITHOLOGIC LOG

Lanipuna #1 (continued)

50% BASALT, Type B, as above.
50% BASALT, Type C.
Description: Nonvesicular to slightly vesicular (<.5 mm) vitrophyre with phenocrysts of pyroxene and plagioclase.
Alteration: Variable alteration of glass and feldspar to clay minerals(?). Trace amounts of quartz, pyrite and calcite in veins.

4,260-4,310 40% BASALT, Type B, as above.
40% BASALT, Type D, as above.
20% BASALT, Type C, as above.

4,310-4,330 100% GEL.

4,330-4,350 100% BASALT, Type B.
Description: As above.
Alteration: 50% of the clasts have undergone slight to moderate alteration of groundmass constituents. 50% of the clasts are completely altered to white, friable material. Traces of quartz.

4,350-4,360 75% BASALT, Type B, as above.
25% BASALT, Type C, as above.

4,360-4,400 85% BASALT, Type B, as above.
15% BASALT, Type C, as above.

4,400-4,410 100% BASALT, Type B.
Description: As above.
Alteration: 75% of the clasts have undergone slight alteration. 25% of the clasts have undergone intense alteration and are white, friable and usually slickensided.

4,410-4,430 100% BASALT, Type D.
Description: Nonvesicular holocrystalline rock with phenocrysts of black pyroxene ($\leq$1 mm), yellow-brown olivine ($\leq$1 mm), and colorless plagioclase ($\leq$1 mm) set in a fine crystalline groundmass of plagioclase and pyroxene.
Alteration: 80% have some alteration of groundmass feldspars. 20% are complete altered to friable material.

LITHOLOGIC LOG

Lanipuna #1 (continued)

4,430-4,440 100% BASALT, Type B.
Description: As above.
Alteration: 80% of the clasts contain moderately altered feldspars. 20% are completely altered to friable material.

4,440-4,470 100% BASALT, Type B.
Description: As above.
Alteration: 25% of the clasts are not altered. 25% are slightly altered. 50% are completely altered to friable material. Trace amounts of quartz and pyrite in veins.

4,470-4,480 45% BASALT, Type D, as above.
40% BASALT, Type B.
Description: As above.
Alteration: Variable, from slight to intense. Some green tint to most clasts indicating chlorite. Groundmass feldspars have a satin luster. Traces of quartz and pyrite.
15% BASALT, Type C.
Description: As above.
Alteration: A few veins of quartz. Abundant pyrite.

4,480-4,500 50% BASALT, Type B.
Description: As above.
Alteration: Moderate alteration to clay and chlorite(?). Abundant veins of quartz and pyrite. Trace amounts of calcite.
25% BASALT, Type D.
Description: As above.
Alteration: Slight green tint to clasts.
25% BASALT, Type C.
Description: As above.
Alteration: Devitrification. Some veins of pyrite, calcite and quartz.

4,500-4,530 100% BASALT, Type B.
Description: As above.
Alteration: Variable, slight to moderate alteration of groundmass minerals. Moderately altered clasts have a green tint, and groundmas feldspars have a satin luster. 10% of all clasts are intensely altered to friable material. Trace amounts of pyrite, calcite and quartz.

LITHOLOGIC LOG

Lanipuna #1 (continued)

4,530-4,540	100% BASALT, Type B. Description: As above. Alteration: Moderate alteration to chlorite and clay. Trace amounts of pyrite, calcite, and quartz.
4,540-4,600	85% BASALT, Type B, as above. 15% BASALT, Type C. Description: Nonvesicular black vitrophyre. Alteration: Devitrification. Fractures are coated with a green, waxy mineral.
4,600-4,620	75% BASALT, Type B, as above. 25% BASALT, Type C, as above.
4,620-4,640	100% BASALT, Type B. Description: As above. Alteration: Variable 25% of all clasts are slightly altered. 60% of all clasts are moderately altered to a soft green-blue mineral. Quartz and pyrite veins are common. 15% of all clasts are intensely altered to white, friable material.
4,640-4,650	100% BASALT, Type B. Description: As above. Alteration: Pervasive alteration of groundmass minerals. Feldspars are chalky white. Interstitial material is gray-green. Trace amounts of quartz and pyrite.
4,650-4,670	85% BASALT, Type B. Description: As above. Alteration: Variable, slight to moderate alteration of groundmass minerals. 15% BASALT, Type C. Description: Nonvesicular vitrophyre with scattered phenocrysts of pyroxene. Alteration: Devitrification.
4,670-4,740	100% BASALT, Type B. Description: As above. Alteration: Variable, slight to moderate. Moderately altered clasts contain white groundmass feldspars and green interstitial material. Trace amounts of pyrite, calcite and quartz in veins or vugs.

LITHOLOGIC LOG

Lanipuna #1 (continued)

4,740-4,760	100% BASALT, Type B. Description: As above. Alteration: Moderate alteration of most clasts. Interstitial groundmass material is a drab green. Scattered crystals of pyrite. Traces of free quartz and calcite.
4,760-4,770	75% BASALT, Type B, as above. 25% BASALT, Type C. Description: Nonvesicular vitrophyre. Alteration: Pervasive devitrification and alteration to a green color. Abundant pyrite disseminations. Trace amounts of quartz veins.
4,770-4,780	85% BASALT, Type B, as above. 15% BASALT, Type C. Description: As above. Alteration: Devitrification. Traces of pyrite.
4,780-4,790	75% BASALT, Type B. Description: As above. Alteration: Variable. Slight to moderate alteration of groundmass minerals. Trace amounts of quartz and pyrite. 25% BASALT, Type C, as above.
4,790-4,800	85% BASALT, Type B. Description: As above. Alteration: Pervasive alteration of groundmass minerals to chlorite. 15% BASALT, Type C, as above.
4,800-4,820	65% BASALT, Type D. Description: Nonvesicular, holocrystalline rock with phenocrysts of pyroxene and plagioclase (<1 mm) set in a groundmass of interlocking feldspar (about .1 mm) and pyroxene (about .1 mm). Alteration: Incipient alteration to chlorite. Trace amounts of calcite. 35% BASALT, Type B, as above.
4,820-4,830	50% BASALT, Type B. Description: As above. Alteration: Incipient alteration of glass to chlorite. 50% BASALT, Type C, as above.

LITHOLOGIC LOG

Lanipuna #1 (continued)

4,830-4,850	75% BASALT, Type B, as above. 25% BASALT, Type C, as above.
4,850-4,860	75% BASALT, Type B. Description: As above. Alteration: Pervasive alteration of groundmass minerals to chlorite. Traces of pyrite and quartz. 25% BASALT, Type C, as above.
4,860-4,870	80% BASALT, Type B. Description: As above. Alteration: Incipient alteration of groundmass constituents. 20% BASALT, Type C, as above.
4,870-4,890	100% BASALT, Type B. Description: As above. Alteration: Pervasive incipient alteration of groundmass feldspars to a frosty color. Incipient alteration of interstitial material to chlorite.
4,890-4,940	100% BASALT, Type B. Description: As above. Alteration: Pervasive incipient alteration of groundmass feldspars to a frosty color. Pervasive alteration of interstitial material to chlorite. 10% of all clasts are intensely altered to white friable material. Trace amounts of pyrite and quartz in cavities.
4,940-4,970	85% BASALT, Type B, as above. 15% BASALT, Type C, as above.
4,970-4,990	75% BASALT, Type B, as above. 25% BASALT, Type C, as above.
4,990-5,000	75% BASALT, Type B. Description: As above. Alteration: Incipient alteration of groundmass material. 25% BASALT, Type D. Description: As above. Alteration: Incipient alteration of feldspars.

LITHOLOGIC LOG

Lanipuna #1 (continued)

5,000-5,020	100% BASALT, Type B. Description: Nonvesicular rock with phenocrysts of yellow-brown olivine(?), black pyroxene and colorless plagioclase set in a gorundmass of feldspar laths and interstitial pyroxene and glass. Alteration: Slight alteration of interstitial material to chlorite. Slight alteration of feldspars to a frosty color. Trace amounts of chalcedony in veins.
5,020-5,040	100% BASALT, Type B. Description: As above. Alteration: Moderate pervasive alteration to chlorite. Minor pyrite and quartz in veins and vugs.
5,040-5,050	50% BASALT, Type B, as above. 50% BASALT, Type D. Description: As above. Alteration: Incipient alteration of groundmass minerals to chlorite.
5,050-5,080	75% BASALT, Type D, as above. 25% BASALT, Type B, as above.
5,080-5,120	100% BASALT, Type B. Description: As above. Alteration: Variable. Incipient to moderate alteration of groundmass constituents to chlorite. Trace amounts of quartz and pyrite in vugs.
5,120-5,130	100% BASALT, Type B. Description: As above. Alteration: Moderate alteration of the groundmass to chlorite. Trace amounts of quartz and calcite in vugs.
5,130-5,170	100% BASALT, Type B. Description: As above. Alteration: Variable. Slight to moderate alteration to chlorite.

LITHOLOGIC LOG

Lanipuna #1 (continued)

5,170-5,180	100% BASALT, Type C. Description: Nonvesicular vitrophyre with scattered phenocrysts of pyroxene and plagioclase. Alteration: Devitrification of glass. Minor amounts of pyrite, chlorite, calcite and quartz on fracture surfaces.
5,180-5,200	50% BASALT, Type B, as above. 50% BASALT, Type C, as above.
5,200-5,210	100% BASALT, Type C. Description: As above. Alteration: Devitrification of glass. Abundant fractures coated with chlorite and pyrite.
5,210-5,240	100% BASALT, Type C. Description: As above. Alteration: Variable chlorite alteration from slight to moderate. Minor intense alteration to friable material. Some frosty white mineralization. Possibly anhydrite or andularia. Traces of pyrite.
5,240-5,250	75% BASALT, Type C, as above. 25% BASALT, Type D. Description: As above. Alteration: Incipient alteration of groundmass minerals.
5,250-5,280	75% BASALT, Type D, as above. 25% BASALT, Type C, as above.
5,280-5,290	100% BASALT, Type B. Description: As above. Alteration: Incipient alteration of groundmass constituents.
5,290-5,300	90% BASALT, Type B, as above. 10% BASALT, Type C, as above.
5,300-5,310	100% BASALT, Type B. Description: As above. Alteration: Variable. Slight to moderate alteration of groundmass constituents. Minor calcite, quartz and pyrite.

LITHOLOGIC LOG

Lanipuna #1 (continued)

5,310-5,330	100% BASALT, Type B. Description: As above. Alteration: Variable as above, with scattered veins of quartz.
5,330-5,360	100% BASALT, Type B. Description: As above. Alteration: Moderate alteration of groundmass constituents to chlorite.
5,360-5,370	100% BASALT, Type B. Description: As above. Alteration: Variable. Slight to moderate.
5,370-5,390	100% BASALT, Type D. Description: As above. Alteration: Incipient alteration of feldspars and pyroxene.
5,390-5,400	100% BASALT, Type B, as above.
5,400-5,410	90% BASALT, Type B, as above. 10% BASALT, Type C, as above.
5,410-5,510	100% BASALT, Type B. Description: As above. Alteration: Pervasive alteration of groundmass feldspars to frosty white material. Partial alteration of interstitial material to chlorite. Traces of calcite and quartz.
5,510-5,530	50% BASALT, Type B, as above. 50% BASALT, Type C, as above.
5,530-5,550	100% BASALT, Type D. Description: As above. Alteration: Abundant chlorite interstitial to feldspar.
5,550-5,560	100% BASALT, Type D, as above.
5,560-5,570	75% BASALT, Type B. Description: As above. Alteration: Moderate. Feldspars are altered to a soft white material. Mafic minerals are altered to chlorite. 25% BASALT, Type D, as above.

LITHOLOGIC LOG

Lanipuna #1 (continued)

5,570-5,580 100% BASALT, Type B.
Description: As above.
Alteration: Interstitial material is altered to chlorite.

5,580-5,640 100% BASALT, Type B.
Description: Nonvesicular, phenocryst-poor rock with abundant feldspar laths in the groundmass.
Alteration: Moderate. Feldspars are frosty or white. Interstitial minerals are altered to chlorite. Trace amounts of calcite and quartz.
Note: Clasts are large and platey.

5,640-5,680 85% BASALT, Type B, as above.
15% BASALT, Type C.
Description: Nonvesicular vitrophyre.
Alteration: Devitrification.

5,680-5,710 100% BASALT, Type B.
Description: Nonvesicular rock with scattered phenocrysts of pyroxene, olivine(?) and plagioclase set in a matrix of feldspar laths and glassy interstitial material.
Alteration: Variable, slight to intense. Highly altered clasts contain abundant nodules of dark green to black chlorite, some apparently pseudomorphous after pyroxene phenocrysts within a pale green to white groundmass. Minor quartz veins with traces of anhydrite(?) and calcite. Minor pyrite associated with chlorite in veins and nodules. Some groundmass alteration consists of dark green to black chlorite intergrown with laths with a silvery satin sheen.

5,710-5,720 100% BASALT, Type B.
Description: As above.
Alteration: Slight to moderate groundmass alteration to chlorite. Trace amounts of pyrite and quartz.

5,720-5,730 80% BASALT, Type C.
Description: Nonvesicular vitrophyre.
Alteration: Variable. Slight devitrification to intense alteration. Highly altered clasts contain veins and nodules of black chlorite set in a pale green to white aphanitic matrix. Minor calcite, pyrite and quartz in veins or vugs.
20% BASALT, Type B, as above.

LITHOLOGIC LOG

Lanipuna #1 (continued)

5,730-5,760	100% BASALT, Type B, as above.
5,760-5,770	80% BASALT, Type B. Description: As above. Alteration: Variable. Moderate to intense alteration to chlorite. 20% BASALT, Type C. Description: As above. Alteration: Variable. Slight to intense alteration to chlorite.
5,770-5,800	100% BASALT, Type B. Description: As above. Alteration: Slight to intense alteration to chlorite.
5,800-5,820	100% BASALT, Type B. Description: As above. Alteration: Slight to intense alteration to chlorite. Minor calcite, quartz and pyrite.
5,820-5,850	100% BASALT, Type B. Description: As above. Alteration: Moderate to intense chloritization.
5,850-5,860	80% BASALT, Type B. Description: As above. Alteration: Moderate chloritization. Minor pyrite and calcite. 20% BASALT, Type C. Description: Nonvesicular vitrophyre. Alteration: Devitrification. Minor calcite and pyrite.
5,860-5,870	65% BASALT, Type B, as above. 35% BASALT, Type C, as above.
5,870-5,890	70% BASALT, Type B. Description: As above. Alteration: Moderate chloritization. Trace amounts of quartz and calcite. 30% BASALT, Type C, as above.
5,890-5,900	100% BASALT, Type B, as above.
5,900-5,950	65% BASALT, Type B, as above. 35% BASALT, Type C, as above.

LITHOLOGIC LOG

Lanipuna #1 (continued)

5,950-5,970 100% BASALT, Type D.
Description: Nonvesicular holocrystalline rock with phenocrysts of plagioclase, pyroxene and olivine(?) set in a fine crystalline groundmass of feldspar and pyroxene.
Alteration: Moderate alteration of groundmass minerals.

5,970-5,990 100% BASALT, Type B.
Description: As above.
Alteration: Variable. Slight to moderate groundmass alteration to chlorite. Abundant pyrite crystals. Minor quartz.

5,990-6,020 100% BASALT, Type B.
Description: As above.
Alteration: Moderate groundmass alteration. Minor quartz and pyrite.

6,020-6,040 75% BASALT, Type B, as above.
25% BASALT, Type C, as above.

6,040-6,050 75% BASALT, Type B.
Description: As above.
Alteration: Moderate groundmass alteration to chlorite. Minor quartz and pyrite in vugs.
25% BASALT, Type C.
Description: Nonvesicular vitrophyre.
Alteration: Variable. Slight to moderate alteration to chlorite. Trace amounts of chlorite and pyrite in fractures.

6,050-6,060 No sample.

6,060-6,080 85% BASALT, Type B.
Description: As above.
Alteration: Variable. Moderate to intense alteration to chlorite. Chlorite replaces mafic minerals and also forms nodules. Quartz and pyrite are abundant (<1%) in fractures and vugs. Trace amounts of brown mica.
15% BASALT, Type C, as above.

6,080-6,090 100% BASALT, Type B.
Description: As above.
Alteration: Slight to intense alteration to chlorite. Minor quartz and pyrite.

LITHOLOGIC LOG

Lanipuna #1 (continued)

6,090-6,110 100% BASALT, Type B.
Description: As above.
Alteration: Slight. Chlorite replaces pyroxene. Minor quartz.

6,110-6,120 100% BASALT, Type B.
Description: As above.
Alteration: Negligible.

6,120-6,150 80% BASALT, Type B.
Description: As above.
Alteration: Trace amounts of quartz.
20% BASALT, Type C.
Description: As above.
Alteration: Trace amounts of chlorite on fracture surfaces.

6,150-6,160 90% BASALT, Type B.
Description: As above.
Alteration: Slight groundmass alteration to chlorite.
10% BASALT, Type C, as above.

6,160-6,190 100% BASALT, Type D.
Description: As above.
Alteration: 90% of all clasts have undergone slight alteration of groundmass feldspars. 10% of all clasts are intensely altered to white friable material.

6,190-6,210 80% BASALT, Type B.
Description: As above.
Alteration: Variable. Slight to moderate alteration of groundmass minerals to chlorite. Minor amounts of quartz and pyrite in vugs and fractures.
20% BASALT, Type C.
Description: As above.
Alteration: Variable with fractures of chlorite, pyrite and quartz. Trace amounts of biotite.

6,210-6,220 55% BASALT, Type C.
Description: As above.
Alteration: As above, but no biotite.
45% BASALT, Type B, as above.

LITHOLOGIC LOG

Lanipuna #1 (continued)

6,220-6,230 50% BASALT, Type B, as above.
50% BASALT, Type C.
Description: As above.
Alteration: Variable alteration to chlorite. Abundant fractures with pyrite and quartz. Trace amounts of biotite.

6,230-6,260 100% BASALT, Type B.
Description: As above.
Alteration: Moderate to intense alteration to chlorite. Abundant fractures and vugs with pyrite, chlorite and quartz. Trace amounts of biotite.

6,260-6,280 85% BASALT, Type B, as above, but no biotite.
15% BASALT, Type C.
Description: As above.
Alteration: Variable. Minor amount of fractures with quartz.

6,280-6,290 100% BASALT, Type B.
Description: As above.
Alteration: Variable. Slight to intense groundmass alteration to chlorite. Pyrite is abundant, filling fractures and as dissemenations. Quartz is minor in fractures.

6,290-6,300 85% BASALT, Type B.
Description: As above.
Alteration: Moderate groundmass alteration to chlorite. Abundant pyrite. Minor quartz.
15% BASALT, Type C.
Description: As above.
Alteration: Moderate groundmass alteration to chlorite. Minor nodules of chlorite. Abundant pyrite. Minor quartz.

6,300-6,320 85% BASALT, Type B, as above.
15% BASALT, Type C.
Description: As above.
Alteration: Variable, fresh black glass to devitrified, chlorite-rich rock. Abundant pyrite. Minor quartz.

6,320-6,330 No sample.

LITHOLOGIC LOG

Lanipuna #1 (continued)

6,330-6,350 100% BASALT, Type B.
Description: As above.
Alteration: Variable, slight to intense alteration. Minor pyrite and quartz.

6,350-6,360 80% BASALT, Type B.
Description: Nonvesicular rock with abundant plagioclase (≤3 mm) and minor pyroxene phenocrysts.
Alteration: Variable groundmass alteration to chlorite. Abundant pyrite. Minor quartz.
20% BASALT, Type C.
Description: Nonvesicular vitrophyre.
Alteration: None to slight.

6,360-6,380 90% BASALT, Type B.
Description: Nonvesicular rock with scattered phenocrysts of plagioclase and pyroxene.
Alteration: Variable, none to intense. Minor pyrite.
10% BASALT, Type C, as above.

6,380-6,390 50% BASALT, Type B.
Description: As above.
Alteration: Slight groundmass alteration.
50% BASALT, Type D.
Description: As above.
Alteration: Slight groundmass alteration.

6,390-6,400 100% BASALT, Type B.
Description: As above.
Alteration: Variable, moderate to intense alteration of feldspar and of mafic minerals to chlorite. Minor pyrite. Trace amounts of quartz.

6,400-6,410 No sample.

6,410-6,490 85% BASALT, Type B, as above.
15% BASALT, Type C, as above.

6,490-6,500 90% BASALT, Type B.
Description: As above.
Alteration: Variable, slight to moderate alteration of groundmass minerals. Minor pyrite.
10% BASALT, Type C, as above.

LITHOLOGIC LOG

Lanipuna #1 (continued)

6,500-6,510 100% BASALT, Type D.
Description: As above.
Alteration: Slight alteration to chlorite. Traces of pyrite and quartz.

6,510-6,520 100% BASALT, Type D.
Description: As above.
Alteration: 90% of all clasts are slightly altered. 10% have been intensely altered to white friable material. Trace amounts of quartz.

6,520-6,530 85% BASALT, Type D, as above.
15% BASALT, Type C, as above.

6,530-6,540 80% BASALT, Type B, as above.
20% BASALT, Type C, as above.

6,540-6,550 60% BASALT, Type B, as above.
40% BASALT, Type D.
Description: As above.
Alteration: Slight alteration of mafic minerals to chlorite.

6,550-6,560 75% BASALT, Type B, as above.
15% BASALT, Type D, as above.
10% BASALT, Type C.
Description: As above.
Alteration: Variable, slight to moderate. Minor chlorite and pyrite in fractures.

6,560-6,570 80% BASALT, Type B, as above.
20% BASALT, Type C, as above.

6,570-6,600 85% BASALT, Type B.
Description: As above.
Alteration: Moderate groundmass alteration to chlorite. Trace amounts of chlorite and quartz lining fractures.
15% BASALT, Type C.
Description: As above.
Alteration: Slight, trace amounts of hematite stain. Minor pyrite and chlorite in fractures or as disseminations.

LITHOLOGIC LOG

Lanipuna #1 (continued)

6,600-6,610 70% BASALT, Type B.
Description: As above.
Alteration: Slight to moderate. Abundant pyrite.
30% BASALT, Type C.
Description: As above.
Alteration: Variable, slight to moderate groundmass alteration. Minor pyrite and chlorite in fractures. Trace amounts of quartz.

6,610-6,650 80% BASALT, Type B.
Description: As above.
Alteration: Moderate.
20% BASALT, Type C, as above, with trace amounts of anhydrite.

6,650-6,660 80% BASALT, Type D.
Description: As above.
Alteration: Pervasive alteration of groundmass feldspar. Interstitial material has a faint blue-green tint. Minor pyrite disseminated in the groundmass.

6,660-6,670 No sample.

6,670-6,680 100% BASALT, Type D, as above.

6,680-6,700 50% BASALT, Type D, as above.
50% BASALT, Type B.
Description: As above.
Alteration: Slight.

6,700-6,760 100% BASALT, Type D, as above.

6,760-6,770 90% BASALT, Type D, as above.
10% BASALT, Type C.
Description: As above.
Alteration: None to slight.

6,770-6,780 50% BASALT, Type D, as above.
50% BASALT, Type C, as above.

6,780-6,800 75% BASALT, Type B.
Description: As above.
Alteration: Slight to moderate alteration of feldspars.
25% BASALT, Type C, as above.

LITHOLOGIC LOG

Lanipuna #1 (continued)

6,800-6,810 50% BASALT, Type B.
Description: As above.
Alteration: Moderate alteration of feldspar laths and of interstitial material to chlorite.
50% BASALT, Type C, as above.

6,810-6,860 85% BASALT, Type B, as above.
15% BASALT, Type C, as above.

6,860-6,870 85% BASALT, Type B.
Description: As above.
Alteration: Moderate to intense. Intensely altered clasts (about 20%) are friable.
15% BASALT, Type C, as above.

6,870-6,880 100% BASALT, Type B.
Description: As above.
Alteration: Variable, slight to intense alteration of feldspar laths to a white, chalky substance and of interstitial material to chlorite. Minor chlorite nodules.

6,880-6,890 90% BASALT, Type B.
Description: As above.
Alteration: Moderate groundmass alteration. Minor pyrite.
10% BASALT, Type C, as above.

6,890-6,920 80% BASALT, Type B, as above.
20% BASALT, Type C, as above.

6,920-6,930 90% BASALT, Type B.
Description: As above.
Alteration: Variable, slight to intense. Minor pyrite.
10% BASALT, Type C, as above.

6,930-6,950 85% BASALT, Type B.
Description: As above.
Alteration: Variable, moderate to intense alteration. Abundant yellow to yellow-green elongate crystals of epidote(?). Minor pyrite, quartz. Abundant black, metallic mineral in the groundmass.
15% BASALT, Type C, as above.

LITHOLOGIC LOG

Lanipuna #1 (continued)

6,950-6,980	50% BASALT, Type D. Description: As above. Alteration: Moderate pervasive alteration of feldspars. Minor epidote. 50% BASALT, Type B, as above.
6,980-6,990	100% BASALT, Type B. Description: As above. Alteration: Moderate. Minor pyrite.
6,990-7,000	100% BASALT, Type B. Description: As above. Alteration: Variable, slight to moderate.
7,000-7,010	75% BASALT, Type B, as above. 25% BASALT, Type D. Description: As above. Alteration: Slight
7,010-7,020	70% BASALT, Type B. Description: As above. Alteration: Variable, moderate to intense groundmass alteration. Minor pyrite. 30% BASALT, Type C. Description: As above. Alteration: Slight devitrification.
7,020-7,050	85% BASALT, Type B, as above. 15% BASALT, Type C, as above.
7,050-7,080	85% BASALT, Type B. Description: As above. Alteration: Moderate to intense, with dark green and light green patches of alteration minerals. Trace amounts of quartz. Minor pyrite. 15% BASALT, Type C, as above.
7,080-7,100	100% BASALT, Type B. Description: As above. Alteration: Slight to intense. Trace amounts of quartz and pyrite.

LITHOLOGIC LOG

Lanipuna #1 (continued)

7,100-7,110	50% BASALT, Type B, as above. 50% BASALT, Type C. Description: As above. Alteration: Slight devitrification.
7,110-7,130	100% BASALT, Type B, as above.
7,130-7,140	No sample.
7,140-7,150	100% BASALT, Type D. Description: As above. Alteration: Slight alteration of groundmass feldspars to a frosty appearance.
7,150-7,190	100% BASALT, Type D. Description: As above. Alteration: 70% of all clasts have undergone slight groundmass alteration. Many mafic minerals are yellow to yellow brown and could be epidote or amphibole. 30% of all clasts are intensely altered to friable material.
7,190-7,200	100% BASALT, Type B. Description: As above. Alteration: Slight alteration of feldspars to a frosty white color.
7,200-7,220	75% BASALT, Type B. Description: As above. Alteration: As above with trace amounts of quartz in veins. 25% BASALT, Type C. Description: As above. Alteration: Devitrification.
7,220-7,240	75% BASALT, Type B. Description: As above. Alteration: Pervasive slight to intense alteration of feldspars to a chalky white material. 25% BASALT, Type C. Description: As above. Alteration: Completely devitrified.

LITHOLOGIC LOG

Lanipuna #1 (continued)

7,240-7,250	75% BASALT, Type B. Description: As above. Alteration: Variable. Negligible to intense groundmass alteration of feldspars. Trace amounts of yellow and colorless crystals in fractures. 25% BASALT, Type C. Description: As above. Alteration: Variable. Slight devitrification to intense alteration to a chalky pale green or white material.
7,250-7,260	80% BASALT, Type B. Description: As above. Alteration: As above with trace amounts of quartz. 20% BASALT, Type C, as above.
7,260-7,270	85% BASALT, Type D. Description: As above. Alteration: Pervasive alteration of feldspars to a chalky white or pale green material. 15% BASALT, Type C, as above.
7,270-7,280	50% BASALT, Type D, as above. 50% BASALT, Type B, as above.
7,280-7,290	100% BASALT, Type B. Description: As above. Alteration: Pervasive groundmass alteration with abundant colorless prismatic crystals with a satin luster. Trace amounts of quartz in veins. Trace amounts of a black, dendritic mineral.
7,290-7,300	100% BASALT, Type B. Description: As above. Alteration: Variable. Slight to intense groundmass alteration. Trace amounts of pyrite, quartz and epidote in fractures.
7,300-7,320	75% BASALT, Type B, as above. 25% BASALT, Type C. Description: As above. Alteration: Devitrification.
7,320-7,330	No sample.

LITHOLOGIC LOG

Lanipuna #1 (continued)

7,330-7,350	100% BASALT, Type D. Description: As above. Alteration: Pervasive alteration of groundmass feldspars to a chalky pale green material.
7,350-7,360	50% BASALT, Type D, as above. 50% BASALT, Type D. Description: As above. Alteration: Slight.
7,360-7,370	75% BASALT, Type C. Description: As above. Alteration: Devitrification. 25% BASALT, Type D, as above.
7,370-7,390	50% BASALT, Type C. Description: As above. Alteration: Patchy devitrification with traces of pyrite and epidote(?) on fracture surfaces. 50% BASALT, Type D, as above.
7,390-7,400	75% BASALT, Type D, as above. 25% BASALT, Type C, as above.
7,400-7,420	100% BASALT, Type D, as above.
7,420-7,460	75% BASALT, Type D, as above. 25% BASALT, Type C, as above.
7,460-7,470	65% BASALT, Type D, as above. 35% BASALT, Type C, as above.
7,470-7,490	85% BASALT, Type D, as above. 15% BASALT, Type C, as above.
7,490-7,510	100% BASALT, Type B. Description: As above. Alteration: Pervasive alteration of groundmass feldspar to a chalky white substance. Minor calcite. Traces of quartz and yellow-green epidote(?) in fractures. Abundant pyrite on fracture surfaces.

LITHOLOGIC LOG

Lanipuna #1 (continued)

7,510-7,530 100% BASALT, Type B.
Description: As above.
Alteration: Patchy alteration of groundmass feldspars. Minor epidote(?) and pyrite on fracture surfaces.

7,530-7,540 75% BASALT, Type B.
Description: As above.
Alteration: As above, with minor calcite and traces of quartz.
25% BASALT, Type C.
Description: As above.
Alteration: Some spherulitic texctures.

7,540-7,550 100% BASALT, Type B.
Description: As above.
Alteration: Variable. Moderate to intense groundmass alteration of feldspars to chalky white and green material. Trace amounts of quartz.

7,550-7,560 75% BASALT, Type B.
Description: As above.
Alteration: As above, with minor quartz in veins.
25% BASALT, Type C.
Description: As above.
Alteration: Devitrification.

7,560-7,580 85% BASALT, Type B.
Description: As above.
Alteration: Pervasive alteration of groundmass feldspar. Abundant pyrite as disseminations and on fracture surfaces. Minor epidote coating fractures. Traces of calcite and quartz.
15% BASALT, Type C.
Description: As above.
Alteration: Traces of pyrite and epidote.

7,580-7,590 85% BASALT, Type B.
Description: As above.
Alteration: As above, but no quartz.
15% BASALT, Type C, as above.

7,590-7,600 100% BASALT, Type B.
Description: As above.
Alteration: Pervasive groundmass alteration of feldspars to chalky white and pale green substances.

LITHOLOGIC LOG

Lanipuna #1 (continued)

7,600-7,630 100% BASALT, Type B.
Description: As above.
Alteration: Patchy groundmass alteration of feldspars. Minor amounts of epidote and pyrite in fractures. Trace amounts of quartz.

7,630-7,650 100% BASALT, Type B.
Description: As above.
Alteration: Variable. Moderate to intense alteration. Intensely altered clasts are friable and chalky white. Trace amounts of quartz and epidote. Minor pyrite.

7,650-7,660 85% BASALT, Type B.
Description: As above.
Alteration: Variable. Moderate to intense alteration of the groundmass with a satin luster to the alteration.
15% BASALT, Type C.
Description: As above.
Alteration: A few clasts are covered with purple-red hydrous iron oxide.

7,660-7,680 90% BASALT, Type B.
Description: As above.
Alteration: As above, with traces of quartz.
10% BASALT, Type C, as above.

7,680-7,690 50% BASALT, Type B.
Description: As above.
Alteration: Groundmass minerals are altering to a gray-green substance with a satin luster. Traces of pyrite, quartz and white fibrous zeolite.
50% BASALT, Type C.
Description: As above.
Alteration: As above, with coatings of purple-red iron oxide.

7,690-7,700 75% BASALT, Type B, as above.
25% BASALT, Type C, as above.

7,700-7,710 75% BASALT, Type B, as above.
25% BASALT, Type C.
Description: As above.
Alteration: Traces of pyrite. Devitrified groundmass.

LITHOLOGIC LOG

Lanipuna #1 (continued)

7,710-7,740	100% BASALT, Type B, as above.
7,740-7,750	70% BASALT, Type B, as above. 30% BASALT, Type C. Description: As above. Alteration: Traces of hydrous iron oxide.
7,750-7,760	40% BASALT, Type B, as above. 60% BASALT, Type C. Description: As above. Alteration: Variable from devitrification to intense alteration to a green, friable substance. Traces of epidote in vugs. Minor free quartz.
7,760-7,770	85% BASALT, Type D. Description: As above. Alteration: Pervasive alteration of feldspars. Trace amounts of epidote and quartz. 15% BASALT, Type C, as above.
7,770-7,780	No sample.
7,780-7,790	50% BASALT, Type B. Description: As above. Alteration: Pervasive alteration of groundmass feldspars. 50% BASALT, Type C, as above.
7,790-7,800	100% BASALT, Type B, as above.
7,800-7,830	100% BASALT, Type B. Description: As above. Alteration: Variable, slight to moderate groundmass alteration. Trace amounts of pyrite, epidote and zeolite(?) on fracture surfaces.
7,830-7,850	50% BASALT, Type B, as above. 50% BASALT, Type C. Description: As above. Alteration: Intense. Clasts are rounded. Groundmasses are altered to a pale gray-green substance. Lime-green epidote(?) is <u>abundant</u> lining vesicles, as nodules within the groundmass and coating clasts. Traces of free quartz and fibrous white zeolite(?).

LITHOLOGIC LOG

Lanipuna #1 (continued)

7,850-7,860 75% BASALT, Type B, as above.
25% BASALT, Type C, as above.

7,860-7,880 75% BASALT, Type C, as above.
25% BASALT, Type B, as above.

7,880-7,900 100% BASALT, Type C.
Description: Vesicular.
Alteration: 50% of all clasts have undergone some devitrification. Otherwise, they are fresh except for traces of epidote and pyrite in veins. 50% of all clasts have undergone intense alteration and mineralization to a soft gray-green chlorite(?) with abundant epidote in vugs. There is also a minor amount of fibrous white zeolite(?) in vugs.

7,900-7,910 80% BASALT, Type C, as above.
20% BASALT, Type B.
Description: As above.
Alteration: Variable. Slight to intense groundmass alteration.

7,910-7,920 100% BASALT, Type C, as above.

7,920-7,930 100% BASALT, Type C.
Description: Slightly vesicular.
Alteration: 20% of all clasts are fairly fresh and unaltered. 80% of all clasts have undergone pervasive groundmass alteration to a pale green substance. Vesicles are partially or completely filled with a soft, dark green material and some pyrite.

7,930-7,950 100% BASALT, Type C.
Description: Slightly vesicular.
Alteration: All clasts have undergone intense alteration as described above.

7,950-7,960 70% BASALT, Type C, as above.
30% BASALT, Type B.
Description: As above.
Alteration: Variable groundmass alteration, moderate to intense.

LITHOLOGIC LOG

Lanipuna #1 (continued)

7,960-7,970	50% BASALT, Type C, as above. 50% BASALT, Type B, as above.
7,970-7,980	75% BASALT, Type B, as above. 25% BASALT, Type C, as above.
7,980-7,990	100% BASALT, Type B. Description: As above. Alteration: Pervasive groundmass alteration of feldspar.
7,990-8,000	75% BASALT, Type B, as above. 25% BASALT, Type D. Description: As above. Alteration: Slight, devitrification.
8,000-8,010	80% BASALT, Type D. Description: As above. Alteration: Slight green cast to the groundmass feldspar. Minor amounts of disseminated pyrite. 20% BASALT, Type C, as above.
8,010-8,020	75% BASALT, Type B. Description: As above. Alteration: Slight alteration of groundmass feldspar. Minor pyrite. 25% BASALT, Type D, as above.
8,020-8,040	100% BASALT, Type B, as above.
8,040-8,070	50% BASALT, Type B, as above. 50% BASALT, Type D. Description: As above. Alteration: Groundmass feldspars are altered to a green color in patches. Trace amounts of pyrite in veins.
8,070-8,080	100% BASALT, Type D. Description: Scattered phenocrysts of olivine set in a holocrystalline matrix of feldspar and mafic minerals. Alteration: Groundmass constituents are altered to a green substance. Trace amounts of fracture fillings of soft green material.

LITHOLOGIC LOG

Lanipuna #1 (continued)

8,080-8,100 60% BASALT, Type D.
Description: As above.
Alteration: Slight groundmass alteration.
40% BASALT, Type B.
Description: As above.
Alteration: Slight alteration of feldspars.

8,100-8,110 60% BASALT, Type B, as above.
40% BASALT, Type C.
Description: As above.
Alteration: As above, with traces of soft green material in veins.

8,110-8,130 100% BASALT, Type B.
Description: As above.
Alteration: Trace amounts of pyrite and green material. Otherwise, the rock is only devitrified.

8,130-8,160 100% BASALT, Type B.
Description: As above.
Alteration: Variable slight to moderate alteration of groundmass feldspars. Trace amounts of calcite and pyrite.

8,160-8,180 50% BASALT, Type B, as above.
50% BASALT, Type C.
Description: As above.
Alteration: Devitrification.

8,180-8,190 100% BASALT, Type B.
Description: As above.
Alteration: Moderate alteration of groundmass feldspar. Trace amounts of pyrite.

8,190-8,200 50% BASALT, Type B, as above.
50% BASALT, Type D.
Description: As above.
Alteration: Groundmass feldspars are altered to a white substance. Interstitial material is green. Trace amounts of disseminated pyrite.

LITHOLOGIC LOG

Lanipuna #1 (continued)

8,200-8,210	75% BASALT, Type C. Description: As above. Alteration: Devitrification of the groundmass. Mafic phenocrysts are replaced by chlorite(?). 25% BASALT, Type B. Description: As above. Alteration: Slight to moderate alteration of groundmass feldspars.
8,210-8,220	75% BASALT, Type D, as above. 25% BASALT, Type C, as above.
8,220-8,240	100% BASALT, Type B. Description: As above. Alteration: Variable, slight to intense groundmass alteration. Intensely altered clasts are friable.
8,240-8,250	85% BASALT, Type D. Description: As above. Alteration: As above. 15% BASALT, Type C, as above.
8,250-8,280	100% BASALT, Type B. Description: As above. Alteration: Variable, slight to moderate alteration of groundmass constituents.
8,280-8,330	100% BASALT, Type D. Description: As above. Alteration: Slight to moderate alteration of groundmass minerals.
8,330-8,340	75% BASALT, Type D, as above. 25% BASALT, Type C. Description: As above. Alteration: Devitrification of the groundmass. trace amounts of soft, waxy chlorite(?) on fracture surfaces.
8,340-8,350	100% BASALT, Type B. Description: As above. Alteration: Slight alteration of groundmass feldspars.

LITHOLOGIC LOG

Lanipuna #1 (continued)

8,350-8,360	50% BASALT, Type D, as above. 50% BASALT, Type C, as above.
8,360-8,380	35% BASALT, Type C, as above. 35% BASALT, Type B. Description: As above. Alteration: Slight to moderate alteration of groundmass constituents. 30% BASALT, Type D, as above.
8,380-8,390	70% BASALT, Type B, as above. 30% BASALT, Type C, as above.

APPENDIX C

Lanipuna #1, Temperature Surveys

TABLE 4. Temperature Surveys, Lanipuna #1

No.	Date	Time	Comments
1	3-6-81	0752	Bottomhole temperature at 1,527 feet, 3 hours after drilling
2	3-11-81	1740	Bottomhole temperature at 2,212 feet, 2-1/2 hours after drilling.
3	3-14-81	2030	Bottomhole temperature at 2,781 feet, 3 hours after drilling.
4	3-19-81	1500	Bottomhole temperature at 3,308 feet, 3 hours after drilling.
5	3-21-81	0830	Bottomhole temperature at 3,520 feet, 3 hours after drilling.
6	3-21-81	1800	Log of the hole at 100-foot intervals from 2,800 feet to 3,500 feet, 12 hours after drilling.
7	3-22-81	1830	Log of the hole at 100-foot intervals from 3,000 feet to 3,510 feet, 32 hours after drilling.
8	3-23-81	1130	Log of the hole at 100-foot intervals from 3,000 feet to 3,510 feet, 52 hours after drilling.
9	4-4-81	0800	Bottomhole temperature at 4,595 feet, 3 hours after drilling.
10	4-4-81	1700	Log of the hole at 200-foot intervals from 3,000 feet to 4,600 feet, 10 hours after drilling.
11	4-5-81	1400	Log of the hole from 3,000 feet to 4,600 feet, 35 hours after drilling.
12	4-6-81	1030	Log of the hole from 3,000 feet to 4,600 feet, 54 hours after drilling.
13	4-11-81	0800	Bottomhole temperature at 5,800 feet, 3 hours after drilling.

Table 4 (continued)

14	4-11-81	1800	Kuster bomb malfunctioned.
15	4-12-81	1800	Log of the hole from 4,000 feet to 5,800 feet, 30 hours after drilling. Inaccurate cable counter.
16	4-13-81	1100	Log of the hole from 4,200 feet to 5,800 feet, 50 hours after drilling.
17	4-16-81	1830	Bottomhole temperature at 6,295 feet, 6 hours after drilling.
18	4-19-81	2300	Bottomhole temperature at 7,000 feet, 7 hours after drilling.
19	4-22-81	1430	Log of the hole at 100-foot intervals from 5,600 feet to 7,000 feet, 50 hours after displacing mud with water.
20	5-27-81	1400	Log of the hole at 50- and 100-foot intervals from 6,900 feet to 8,389 feet, 8 hours after displacing mud from the hole with water. Inaccurate cable counter.
21	5-27-81	1700	Log of the upper portion of the hole from 1,000 feet to 5,275 feet, 16 hours after displacing mud from the hole with water.
22	5-28-81	1600	Log of the hole at 50- and 100-foot intervals from 5,600 feet to 8,390 feet, 36 hours after displacing mud from the hole with water.
WRI	4-22-81	1600	Log of the upper half of the hole, 56 hours after displacing mud from the hole with water.

TEMPERATURE LOG

Lanipuna #1

Survey #1 3/6/81 7:52 AM

Logged by GeothermEx, Inc.

Purpose: Bottom hole temperature approximately 3 hours after drilling.

1,527 feet at 8:04 AM = 118.0

at 8:12 AM = 118.7

Two maximum thermometers = 100°F

TEMPERATURE LOG

Lanipuna #1

Survey #2 3/11/81 5:40 PM

Logged by GeothermEx, Inc.

Purpose: Bottom hole temperature approximately 2-1/2 hours after circulation at 2,212 feet.

Maximum reading thermometer #1 = 128°F

Maximum reading thermometer #2 = 130°F

TEMPERATURE LOG

Lanipuna #1

Survey #3 3/14/81 8:30 PM

Logged by GeothermEx, Inc.

Purpose: Bottom hole temperature approximately 3 hours after circulation at 2,781 feet.

Maximum reading thermometer #1 = 150°F

Maximum reading thermometer #2 = 154°F

Maximum reading thermometer #3 = 155°F

On bottom for 15 minutes.

Approximately 4.3°F/100 feet between surveys #2 and #3.

TEMPERATURE LOG

Lanipuna #1

Survey #4 3/19/81 3:00 PM

Logged by GeothermEx, Inc.

Purpose: Bottom hole temperature approximately 3 hours after circulation at 3,308 feet.

Maximum reading thermometer #1 at 3,308 feet = 194°F

Maximum reading thermometer #2 at 3,308 feet = 180°F

Maximum reading thermometer #1 at 3,000 feet = 158°F

Maximum reading thermometer #2 at 3,000 feet = 162°F

Maximum reading thermometer #1 at 2,800 feet = 154°F

TEMPERATURE LOG

Lanipuna #1

Survey #5 3/21/81 8:30 AM

Logged by GeothermEx, Inc.

Purpose: Bottom hole temperature approximately 3 hours after circulation at 3,520 feet.

Maximum reading thermometer #1 = 188°F
(maximum temperature to 220°F)

Maximum reading thermometer #2 = 188°F
(maximum temperature to 220°F)

Maximum reading thermometer #3 = <200°F
(temperature range 200-500°F)

Maximum reading thermometer #4 = <200°F
(temperature range 200-500°F)

TEMPERATURE LOG

Lanipuna #1

Survey #6 3/21/81 6:00 PM

Logged by GeothermEx, Inc.

Purpose: To log the hole at 100-foot intervals from total depth to 2,800 feet approximately 12 hours after circulation.

Run #1

Maximum reading thermometer #1, #2, #3 at 3,500 feet = 216°F, 216°F, 216°F
Maximum reading thermometer #4, #5, #6 at 3,400 feet = 200°F, 200°F, 200°F

Run #2

Maximum reading thermometer #1, #2, #3 at 3,300 feet = 198°F, 198°F, 195°F
Maximum reading thermometer #4, #5, #6 at 3,200 feet = 186°F, 188°F, 188°F

Run #3

Maximum reading thermometer #1, #2 at 3,100 feet = 182°F, 180°F
Maximum reading thermometer #3, #4 at 3,000 feet = 176°F, 178°F
Maximum reading thermometer #5, #6 at 2,900 feet = 180°F, 180°F

TEMPERATURE LOG

Lanipuna #1

Survey #7 3/22/81 6:30 PM

Logged by GeothermEx, Inc.

Purpose: To log the hole at 100-foot intervals from total depth up at approximately 32 hours after circulation.

Depth, in feet	°F
3,510	258, 260
3,410	245
3,300	217
3,200	220, 220
3,100	215, 215
3,000	208

TEMPERATURE LOG

Lanipuna #1

Survey #8 3/23/81 11:30 AM

Logged by GeothermEx, Inc.

Purpose: To log the hole at 100-foot intervals from total depth up at approximately 52 hours after circulation.

Depth, in feet	°F
3,510	270, 270
3,400	257
3,300	245, 245
3,200	235, 235
3,100	230, 230
3,000	222, 222

TEMPERATURE LOG

Lanipuna #1

Survey #9 4/4/81 8:00 AM

Logged by GeothermEx, Inc.

Purpose: Bottom hole temperature at approximately 3 hours after circulation at 4,595 feet. Circulated one hour prior to pulling out of hole.

Maximum reading thermometer at 4,595 feet = 240°F, 240°F

Maximum reading thermometer at 4,495 feet = 240°F

Maximum reading thermometer at 4,095 feet = 195°F, 195°F

TEMPERATURE LOG

Lanipuna #1

Survey #10 4/4/81 5:00 PM

Logged by GeothermEx, Inc.

Purpose: To log the open hole approximately 10 hours after circulation.

Depth, in feet	Kuster °F
3,000	203
3,200	209
3,400	212
3,600	217
3,800	223
4,000	228
4,200	238
4,400	259
4,600	291

TEMPERATURE LOG

Lanipuna #1

Survey #11 4/5/81 2:00 PM

Logged by GeothermEx, Inc.

Purpose: To log the open hole approximately 35 hours after circulation.

Depth, in feet	Kuster °F
3,000	222
3,200	230
3,400	236
3,600	241
3,800	247
4,000	255
4,100	262
4,200	270
4,300	279
4,400	291
4,500	302
4,600	317

Maximum reading thermometers = 317°F, 317°F, 312°F

TEMPERATURE LOG

Lanipuna #1

Survey #12 4/6/81 10:30 AM

Logged by GeothermEx, Inc.

Purpose: To log the open hole approximately 54 hours after circulation.

Depth, in feet	Kuster °F
3,000	233
3,200	242
3,400	247
3,600	257
3,800	263
4,000	273
4,100	279
4,200	287
4,300	296
4,400	309
4,500	316
4,600	323

Maximum reading thermometers = 322°F, 322°F, 317°F

TEMPERATURE LOG

Lanipuna #1

Survey #13 4/11/81 8:00 AM

Logged by GeothermEx, Inc.

Purpose: Bottom hole temperature approximately 3 hours after drilling at 5,800 feet.

Begin Clock:	5:40 AM
On Bottom:	6:30 AM
Pull Out of Hole:	7:00 AM

Maximum reading thermometers = 346°F, 345°F, 348°F
(located approximately 15 feet above kuster bomb)

Kuster bomb = 372°F

TEMPERATURE LOG

Lanipuna #1

Survey #14 4/11/81 6:00 PM

Logged by GeothermEx, Inc.

Purpose: Survey the open hole approximately 10 hours after circulation.

Kuster bomb malfunctioned; 3 maximum reading thermometers lost down hole.

TEMPERATURE LOG

Lanipuna #1

Survey #15 4/12/81 6:00 PM

Logged by GeothermEx, Inc.

Purpose: To log the open hole approximately 30 hours after circulation.

Depth, in feet	Kuster °F
4,000	255
4,200	263
4,400	271
4,600	284
5,000	313
5,100	352
5,200	370
5,300	385
5,400	400
5,500	416
5,600	436
5,700	454
5,800	462

Note: Inaccurate cable counter.

TEMPERATURE LOG

Lanipuna #1

Survey #16 4/13/81 11:00 AM

Logged by GeothermEx, Inc.

Purpose: To log the open hole approximately 50 hours after circulation.

Depth, in feet	°F
4,200	261
4,400	271
4,600	280
4,800	295
5,000	327
5,200	367
5,300	387
5,400	402
5,500	416
5,600	434
5,700	452
5,800	456

TEMPERATURE LOG

Lanipuna #1

Survey #17 4/16/81 6:30 PM

Logged by GeothermEx, Inc.

Purpose: Bottom hole temperature approximately 6 hours after circulation at 6,295 feet.

Kuster bomb = 323°F
Maximum reading thermometer #1 (0-500°F) = 340°F
Maximum reading thermometer #2 (0-400°F) = 335°F

TEMPERATURE LOG

Lanipuna #1

Survey #18 4/19/81 11:00 PM

Logged by GeothermEx, Inc.

Purpose: Bottom hole temperature approximately 6 hours after circulation of 1 hour at 7,000 feet.

Kuster bomb - 442°F
Maximum reading thermometer #1 (0-500°F) = 470°F
Maximum reading thermometer #2 (0-400°F) = 400°plus F

TEMPERATURE LOG

Lanipuna #1

Survey #19 4/22/81 2:30 PM

Logged by GeothermEx, Inc.

Purpose: To log the open hole from 6,000 feet to 7,000 feet.

Depth, in feet	Kuster °F
5,600	433
5,800	442
6,000	444
6,100	448
6,200	443
6,300	445
6,400	453
6,500	463
6,600	478
6,700	479
6,800	494
6,900	513
7,000	529

TEMPERATURE LOG

Lanipuna #1

Survey #20 5/27/81 2:00 PM

Logged by GeothermEx, Inc.

Purpose: To log the open hole 8 hours after displacing mud from the hole with cold water.

Depth, in feet	Kuster °F
6,900	377
7,000	389
7,100	402
7,200	418
7,300	434
7,400	444
7,500	454
7,600	465
7,700	481
7,750	492
7,800	513
7,850	535
7,900	549
7,950	560
8,000	568
8,050	586
8,100	601
8,200	---
8,300	---
8,389	642

Note: Inaccurate cable counter.

TEMPERATURE LOG

Lanipuna #1

Survey #21 5/27/81 5:00 PM

Logged by GeothermEx, Inc.

Purpose: To log the upper portion of the hole 16 hours after displacing mud from the hole with cold water.

Depth, in feet	°F	Depth, in feet	°F
1,000	119.9	3,600	218.9
1,100	120.0	3,625	219.6
1,200	123.2	3,650	220.4
1,300	124.5	3,675	221.2
1,400	127.3	3,700	221.9
1,500	130.1	3,725	222.2
1,600	133.9	3,750	222.7
1,700	138.0	3,775	223.3
1,800	142.1	3,800	223.7
1,900	146.8	3,825	224.1
2,000	151.1	3,850	224.3
2,100	155.3	3,875	224.7
2,200	158.5	3,900	225.6
2,300	161.0	3,925	227.5
2,400	164.4	3,950	229.1
2,500	169.7	3,975	230.3
2,600	175.3	4,000	231.3
2,700	181.0	4,025	232.4
2,800	186.5	4,050	233.6
2,900	191.8	4,075	234.7
3,000	196.9	4,100	236.1
3,100	201.4	4,125	237.4
3,200	205.4	4,150	238.4
3,300	209.2	4,175	239.0
3,400	213.0	4,200	240.1
3,450	214.7	4,225	241.0
3,475	215.5	4,250	241.8
3,500	216.0	4,275	242.9
3,525	216.2	4,300	244.0
3,550	217.4	4,325	245.1
3,575	218.0	4,350	246.0

TEMPERATURE LOG

Lanipuna #1

Survey #21 (continued)

Depth, in feet	°F
4,375	247.0
4,400	248.0
4,425	248.9
4,450	249.8
4,475	250.5
4,500	250.8
4,525	251.1
4,550	251.5
4,575	252.1
4,600	253.3
4,625	254.7
4,650	255.9
4,675	256.5
4,700	257.4
4,725	258.3
4,750	259.5
4,775	260.8
4,800	261.9
4,825	263.4
4,850	265.2
4,875	267.3
4,900	269.5
4,925	271.8
4,950	273.8
4,975	275.7
5,000	277.6
5,025	279.0
5,050	281.4
5,075	283.7
5,100	285.9
5,125	288.3
5,150	290.7
5,175	292.3
5,200	293.8
5,225	295.8
5,250	298.1
5,275	300.2

TEMPERATURE LOG

Lanipuna #1

Survey #22 5/28/81 4:00 PM

Logged by GeothermEx, Inc.

Purpose: To log the open hole 36 hours after displacing mud from the hole with cold water.

Depth, in feet	Kuster °F
5,600	372
5,800	376
5,900	377
6,010	377
6,100	380
6,200	379
6,300	383
6,400	388
6,600	402
6,700	414
6,800	423
7,000	441
7,200	482
7,300	500
7,400	516
7,500	525
7,600	535
7,700	549
7,750	555
7,800	564
7,850	*570
7,900	593
7,950	616
8,000	636
8,100	649
8,200	665
8,300	---
8,390	**686+

* Clock stopped at 7,850. Temperatures below 7,850 were based on evidence of stylus kicks during movement of the Kuster instrument as it was lowered from station to station.

** The maximum temperature that can be recorded on a Kuster instrument.

W.R.I. - TEMPERATURE SURVEY

Date: April 22, 1981, Time 3-4 p.m., By W.R.I.
Purpose: To log the upper half of the hole, 56 hours after displacing mud from the hole with water

Depth, in feet	°F
3,000	252.9
3,500	268.3
3,550	269.8
3,600	271.8
3,650	274.3
3,700	277.3
3,750	280.5
3,800	284.2
3,850	288.5
3,900	290.4
3,950	291.8
4,000	294.4
4,050	296.4
4,100	299.0
4,150	301.5
4,200	303.9
4,250	306.4
4,300	309.0
4,350	311.9
4,400	314.9
4,450	318.2
4,500	321.7
4,550	325.2

APPENDIX D

Lanipuna #1, Pump Tests and Subsequent Temperature Surveys

Table 5. Lanipuna #1, Pump Tests

Test #1: 20,160 gallons of water were pumped at 168 gpm and 600 psi.

Test #2: 10,200 gallons of water were pumped at 170 gpm and 600 psi.

Test #3: 32,550 gallons of water were pumped at 105 gpm and 450 psi.

W.R.I. - TEMPERATURE SURVEY

Date: April 23, 1981, By W.R.I.

Purpose: To log the hole following pump test #1.

Depth, in feet	°F
100	84.5
500	88.0
1,000	89.7
1,500	93.9
2,000	100.7
2,500	109.6
3,000	121.0
3,500	136.1
3,600	143.3
3,700	157.8
3,800	164.7
3,900	165.1
4,000	156.5
4,100	161.4
4,200	168.5
4,300	176.7
4,400	185.7
4,500	192.3
4,600	205.2
4,700	215.2
4,800	223.7
4,900	237.2
5,000	249.2
5,100	259.6
5,200	274.6
5,300	283.9
5,400	296.9
5,500	309.5
5,600	316.5
5,700	333.6
5,800	338.7
5,820	341.0

W.R.I. - TEMPERATURE SURVEY

Date: April 23, 1981, By W.R.I.

Purpose: To log the hole following pump test #2.

Depth, in feet	°F
1,000	87.9
1,500	91.9
2,000	97.8
2,500	106.0
3,000	117.0
3,500	113.2
3,600	143.5
3,700	153.1
3,800	164.8
3,900	168.4
4,000	149.3
4,100	150.6
4,200	158.0
4,300	163.5
4,400	170.5
4,500	175.7
4,600	187.0
4,700	195.6
4,800	201.6
4,900	212.2
5,000	223.6
5,100	232.3
5,200	245.0
5,300	250.4
5,400	265.4
5,500	274.5
5,600	279.9
5,700	297.7
5,800	302.1
5,900	308.2
6,000	325.0

W.R.I. - TEMPERATURE SURVEY

Date: April 24, 1981, Time 8-10 a.m., By W.R.I.

Purpose: To log the hole after pump test #3

Depth, in feet	1st Run °F	2nd Run °F	Depth, in feet	1st Run °F	2nd Run °F
3,500	120.0	---	4,350	---	162.6
3,800	146.8	157.3	4,375	---	164.2
3,850	145.5	147.3	4,400	153.1	165.8
3,875	141.6	149.7	4,500	157.7	---
3,900	145.8	159.5	4,600	166.6	---
3,925	145.9	160.7	4,700	172.2	---
3,950	131.5	159.5	4,800	178.3	---
3,975	133.4	144.4	4,900	187.3	---
4,000	136.2	146.4	5,000	196.4	---
4,025	133.0	148.9	5,100	205.3	---
4,050	135.0	146.5	5,200	217.0	---
4,075	136.1	147.4	5,300	225.5	---
4,100	136.7	148.7	5,400	242.0	---
4,125	---	149.6	5,500	246.5	---
4,150	---	150.6	5,600	253.3	---
4,175	---	151.2	5,700	269.8	---
4,200	142.0	152.8	5,800	271.7	---
4,225	---	154.7	5,900	278.6	---
4,250	---	155.4	6,000	290.7	---
4,275	---	156.7	6,100	299.3	---
4,300	147.4	158.7	6,200	322.5	---
4,325	---	160.7	6,300	326.0	---

APPENDIX E

Lanipuna #1, Mud Chemistry

Table 6. Mud Chemistry of Lanipuna #1

Date	Tour	Time	wt. #/gal	visc. sec/qt.	water loss, cc	pH	% solids	wall-cake	chl. mg/l	Note
3-17	M	0300	8.9	43	---	9	1	---	---	a
3-19	M	0600	9.2	42	---	9	---	---	---	a
3-31	E	1600	8.3	32	11	12	---	---	---	b
4-2	M	0600	8.5	33	9.8	11	Trace	---	---	b
4-3	M	0300	8.6	36	9	11	Trace	2/32	---	b
4-6	E	2000	8.6	---	8	9.5	1/4	---	---	b
4-8	D	0800	8.85	34	8.6	10.5	Trace	2/32	---	b
4-10	M	0300	8.6	32	9.4	10.5	Trace	2/32	<100	b
4-14	M	0600	8.8	33	9.2	10	Trace	2/32	<100	b
4-18	M	0600	8.8	34	10	10	Trace	2/32	<150	b
4-19	M	0300	8.7	33	9.6	10	Trace	2/32	<200	b
5-5	M	0100	8.5	32	10.8	11.5	---	2/32	<200	b
5-23	M	0100	8.5	35	15	8.5	---	4/32	<300	b
5-24	M	0100	8.6	40	10.5	10	Trace	2/32	<200	b
	D	0830	9.0	38.5	10.4	10	1/4	3/32	<200	b
	E	2300	8.8	38	9.6	10.5	1/2	---	<200	b

Notes:

[a]Drilling 12-1/4-inch hole.

[b]Drilling 8-3/4-inch hole.

APPENDIX F

Chemical Analyses of

Test Samples and Drilling Water,

April 22, 1981

AMTECH

Chemical Analysis — Consultation
Research — Product Development

American Technical Laboratories, Inc.
8909 Complex Drive Suite F
San Diego, California 92123
(714) 560 7717

FIELD DATA
Name: LANIPUNA #1
Coll.Date: 4-22-81, blowtest.
T°C:
pH-field:

LAB DATA: All four samples this set collected at blooie outlet. No filtration or preservation performed. All samples contained brown particulates which remained suspended up to time of shipment to the lab.

LABORATORY NO: 0405-81
DATE OF REPORT: 6/2/81
DATE RECEIVED: 4/28/81
IDENTIFICATION: GEX-H/BW
1, 2:05 2066' RU

SPECIES	meq/L	mg/L
pH		6.84
Ca (field acidif: y n)	42.1	844.
Mg (field acidif: y n)	0.05	0.7
Na	173.	3988.
K	0.061	2.4
Li	0.026	0.18
HCO_3	1.0	62.
CO_3	-	-
SO_4	1.54	74.0
Cl	229.	8100.
SiO_2 (moles/L) AA	0.196	11.8
(field dil:)		
Ec μmhos/cm (as rec'd)		25300.
Ec μmhos/cm (diluted)		29530.
DILUTION FOR Ec		1:250
Ec CALCULATED	28180.	
RATIO Ec (calc/obs)	0.954	
CATIONS Σ+	216.	
ANIONS Σ-	231.	
RATIO CATIONS/ANIONS	0.934	
TDS CALC. SUM ALL IONS		
B (moles/L)	0.129	1.40
F	0.00236	0.300
Br		
SiO_2 (color)	0.162	9.76
NH_4		
$NO_2 + NO_3$ as NO_3		

SPECIES	mg/L
Al	
As	
Ba	
Cd	
Cs	
Cu	
Fe	
Hg	
Mn	
Pb	
Rb	
Sb	
Se	
Sr	
U	
V	
Zn	

Additional Field Data*
One of four samples. Blowtest at drilling depth of 7000ft. Hole cased to 3520ft, open below. Displaced drlg mud w/water; circ.2hrs; pull to 800ft and begin blow-down in stages. See sample ident.above for depth of bit time of sample collection. See report on ASHIDA#1 for analysis of drlg.water. Prior to this test drlg.mud Cl was<100 ppm

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Chemical Analysis — Consultation
Research— Product Development

American Technical Laboratories, Inc.
8909 Complex Drive Suite F
San Diego, California 92123
(714) 560 7717

FIELD DATA
Name: LANIPUNA#1
Coll.Date: 4-22-81, blowtest
T°C:
pH-field:

LABORATORY NO: 0405-81
DATE OF REPORT: 6/2/81
DATE RECEIVED: 4/28/81
IDENTIFICATION: GEX-H/BW
2, 3:00 2252'RU

LAB DATA:

SPECIES	meq/L	mg/L
pH		6.88
Ca (field acidif: y n)	44.1	884.
Mg (field acidif: y n)	0.06	0.7
Na	186.	4270.
K	0.064	2.5
Li	0.030	0.21
HCO_3	1.23	75.
CO_3	-	-
SO_4	2.52	121.
Cl	245.	8700.
SiO_2 (moles/L) AA	0.212	12.8
(field dil:)		
Ec µmhos/cm (as rec'd)		25700.
Ec µmhos/cm (diluted)		30630.
DILUTION FOR Ec		1:260
Ec CALCULATED	30250.	
RATIO Ec (calc/obs)	0.988	
CATIONS Σ+	230.	
ANIONS Σ-	249.	
RATIO CATIONS/ANIONS	0.923	
TDS CALC. SUM ALL IONS		
B (moles/L)	0.143	1.55
F	0.00216	0.275
Br		
SiO2 (color.)	0.201	12.1
NH_4		
NO_2 + NO_3 as NO_3		

SPECIES	mg/L
Al	
As	
Ba	
Cd	
Cs	
Cu	
Fe	
Hg	
Mn	
Pb	
Rb	
Sb	
Se	
Sr	
U	
V	
Zn	

Additional Field Data*
Loc:

Well Type/depth(units):

Flow(ℓpm):

See sample 1 for addl data.

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Chemical Analysis — Consultation
Research — Product Development

American Technical Laboratories, Inc.
8909 Complex Drive Suite F
San Diego, California 92123
(714) 560 7717

FIELD DATA
Name: LANIPUNA #1
Coll.Date: 4-22-81, blowtest
T°C:
pH-field:

LABORATORY NO: 0405-81
DATE OF REPORT: 6/2/81
DATE RECEIVED: 4/28/81
IDENTIFICATION: GEX-H/BW
3, 5:00 2252' RU

LAB DATA:

SPECIES	meq/L	mg/L
pH		6.95
Ca (field acidif: y n)	42.0	842.
Mg (field acidif: y n)	<0.008	<0.1
Na	187.	4310.
K	0.061	2.4
Li	0.032	0.22
HCO_3	1.2	75.
CO_3	-	-
SO_4	2.77	133.
Cl	248.	8800.
SiO_2 (moles/L) AA		8.6
(field dil:)		
Ec µmhos/cm (as rec'd)		25500.
Ec µmhos/cm (diluted)		31200.
DILUTION FOR Ec		1:260
Ec CALCULATED	30458.	
RATIO Ec (calc/obs)	0.976	
CATIONS $\Sigma+$	230.	
ANIONS $\Sigma-$	252.	
RATIO CATIONS/ANIONS	0.910	
TDS CALC. SUM ALL IONS		
B (moles/L)	0.141	1.52
F	0.0165	2.10
Br		
SiO_2(color.)	0.137	8.24
NH_4		
$NO_2 + NO_3$ as NO_3		

SPECIES	mg/L
Al	
As	
Ba	
Cd	
Cs	
Cu	
Fe	
Hg	
Mn	
Pb	
Rb	
Sb	
Se	
Sr	
U	
V	
Zn	

Additional Field Data*
Loc:

Well Type/depth(units):

Flow(ℓpm):
See sample 1 for add'l data

AMTECH

Chemical Analysis — Consultation
Research — Product Development

American Technical Laboratories, Inc.
8909 Complex Drive Suite F
San Diego, California 92123
(714) 560 7717

FIELD DATA
Name: LANIPUNA #1
Coll. Date: 4-22-81, blowtest
T°C:
pH-field:

LABORATORY NO: 0405-81
DATE OF REPORT: 6/2/81
DATE RECEIVED: 4/28/81
IDENTIFICATION: GEX-H/BW
4, 3500' RU

LAB DATA:

SPECIES	meq/L	mg/L
pH		6.99
Ca (field acidif: y n)	76.3	1530.
Mg (field acidif: y n)	0.04	0.5
Na	373.	8578.
K	0.21	8.1
Li	0.092	0.64
HCO_3	1.5	92.
CO_3	-	-
SO_4	2.33	112.
Cl	443.	15700.
SiO_2 (moles/L) AA	0.878	52.9
(field dil:)		
Ec µmhos/cm (as rec'd)		42600.
Ec µmhos/cm (diluted)		54990.
DILUTION FOR Ec		1:450
Ec CALCULATED	56090.	
RATIO Ec (calc/obs)	1.020	
CATIONS $\Sigma+$	449.7	
ANIONS $\Sigma-$	446.7	
RATIO CATIONS/ANIONS	1.007	
TDS CALC. SUM ALL IONS		
B (moles/L)	0.496	5.36
F	0.00212	0.270
Br		
SiO_2 (color)	0.453	27.3
NH_4		
$NO_2 + NO_3$ as NO_3		

SPECIES	mg/L
Al	
As	
Ba	
Cd	
Cs	
Cu	
Fe	
Hg	
Mn	
Pb	
Rb	
Sb	
Se	
Sr	
U	
V	
Zn	

Additional Field Data*
Loc:

Well Type/depth(units):

Flow(gpm):
This is last sample of set. and point of lowest blow. See sample 1 for add'l data. Note drilling and temperature data indicate source of fluid at 4000ft.

LABORATORY NO: 0670-80
DATE OF REPORT: August 20, 1980
IDENTIFICATION: ASHIDA #1
Drilling Water

GEOTHERMEX, INC.
5221 Central Avenue
Richmond, CA 94804

SPECIES	mg/L	eq/L
Ca	1.53	7.63-5
Mg	0.557	4.58-5
Na	10.6	4.61-4
K	1.48	3.78-5
HCO_3	18.1	2.97-4
CO_3	-	
CO_2(FREE)		
SO_4	12.0	2.50-4
Cl	2.84	8.01-5
TDS		
pH	7.24	
Ec µmhos/cm @25°	79.5	
Ec µmhos/CALC	68.9	
Ec OBS/CALC	1.024	
CATIONS Σ+	6.20-4	
ANIONS Σ-	6.26-4	

SPECIES	mg/L	eq/L
B	0.093	8.6-6 (a)
SiO_2	24.4	4.05-4 (a)
NH_4		
F	<0.10	5.3-6
S^{2-}		
Fe^{3+}		
Mn^{2+}		
Rb		
Li	0.0017	2.5-7
Sr		
Cs		
Ba		
Hg		

(a) MOLES/L

Analysis by:
AMTECH American Technical Laboratories, Inc.
[illegible] Suite F San Diego, California 92123 (714) 560-7717

APPENDIX G

Lanipuna #1, Drill Bits

Table 7. Lanipuna #1, Drill Bits

No.	Diameter	Make/ Model	Type	Serial No.	Depth, in	Depth, out	Total Footage	Total Hours	Comments
1	12-1/4	Sec. S88	Button	430588	28	102	74	8-1/2	Rerun
2	17-1/2	Smith S47	Button	AX5559	101	650	549	72-1/2	No jets
3	17-1/2	Smith S47	Button	AV2713	650	1,040	390	43	No jets
4	12-1/4	HTC-X44	Button	GX937	1,040	2,212	1,172	74-1/2	
5	12-1/4	HTC-X44	Button	DC649	2,212	2,781	569	46	
6	12-1/4	HTC-X44	Button	C2211	2,781	3,308	527	66-1/2	
7	12-1/4	HTC-X44	Button	DC765	3,308	3,520	212	32-1/2	
8	8-3/4	HTC-J44	Button	VT776	3,520	4,595	1,075	86-1/2	1/2" jets
9	8-3/4	HTC-J44	Button	FT598	4,595	5,795	1,200	103	1/2" jets
10	8-3/4	HTC-J44	Button	---	5,795	6,295	500	40-1/2	9/16" jets
11	8-3/4	HTC-J44	Button	VT853	6,295	7,132	837	72-1/2	9/16" jets
12	8-3/4	HTC-J44	Button	---	7,132	7,132	---	---	Lost cones
	---	HTC-J44	Button	---	7,132	7,140	8	2	Rerun
13	8/3-4	HTC-J44	Button	RV444	7,140	8,048	908	57	9/16" jets
14	8-3/4	HTC-J55	Button	MX140	8,048	8,389	341	25-1/2	9/16" jets